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EDITORIAL

Band Spectra and Chemistry

ABOUT a decade ago the study of band spectra was *in a highly empirical state. It was known that* bands, either in an emission spectrum such as that from a Bunsen flame, or in absorption, were always to be associated with molecules, whilst line spectra came from atoms. Many bands had been observed and measured, some having their origin in molecules familiar to the chemist (*e.g.*, O_2, N_2, NO), whilst others were radiated from groups such as OH, CH, or NH, which *have only a transitory, but nevertheless real, existence.* It is only since the development of the quantum theory that this mass of experimental results has been applied to give us a definite picture of molecular structure. Progress has been so rapid that a point has now been reached which is a landmark in a field largely unknown to chemists. It is marked by the appearance of Dr. W. Jevons' "Report on Band Spectra of Diatomic Molecules," published recently by the Physical Society. The subject is considerably more complicated than that of line spectra, owing very largely to the existence of three types of motion in the molecule. In the first place, it can rotate as a whole, the energy of rotation being governed by the speed of rotation. Secondly, the molecule can vibrate internally, the simplest picture of which would be a backwards and forwards motion along the line joining two nuclei in the molecule. Lastly, the outer electrons in the molecule can move in various orbits. The energy of the molecule differs from orbit to orbit, and when an electron jumps from an orbit of high to another of lower energy the difference between the energies is liberated as radiation in the visible or ultra-violet spectrum. Changes in the rotational and vibrational energy always accompany the electron jump, and the result is the radiation of a series of bands instead of a single line. In addition it is possible for only the rotational energy to change, when bands in the far infra-red are observed, or for the vibrational and rotational energy to change simultaneously when light in the near infra-red is radiated or absorbed. The amazing complexity of much of the experimental material which has been analysed recently is a triumph for the physicist. There emerges a detailed picture of the internal motions in many of the simpler molecules, which is likely to be of supreme importance in the future development of chemistry. Fortunately Dr. Jevons has treated the subject from the experimental standpoint, and has addressed his report "to the physicist who has not hitherto taken up band spectra as a subject for special reading or laboratory work." References to the physical theories are introduced where necessary however, and the nomenclature of the subject, which to the chemist is likely to be one of the greatest stumbling blocks, is treated in full. The main feature of the report of special interest from the chemist's standpoint is the definite picture presented of the electron orbits in simple molecules, and of the vibrational and rotational motions. Chemistry generally deals with the molecule as a unit, and has not hitherto gone far beneath its surface. One still finds in the literature numerous vague references to "activated" molecules, but in the near future this may very well be replaced by a precise statement of the physical state involved. The study of band spectra has also opened up a new field for work on isotopes. The energy of rotation and vibration of the molecule is dependent on mass, and, *a priori*, we might expect bands due to the molecules HCl^{35} and HCl^{37}, or to $B^{11}O$ and $B^{10}O$, for example, to be different. Actually in such cases a duplication of bands is observed, one set being due to each isotope. This becomes more difficult to detect with elements of greater atomic weight, but has nevertheless been observed in bands due to $Hg^{202}H$, $Hg^{198}H$, $Hg^{200}H$, and $Hg^{204}H$. Work of this type has led to the discovery of the new isotopes O^{18}, O^{17}, N^{15}, and C^{13}, which had escaped detection by mass spectrographic methods, since they were indistinguishable from OH_2, OH, NH, and CH. The relative abundance of the three isotopes O^{16}, O^{18}, and O^{17} is given as 630 : 1 : 0·2, and that of N^{14} and N^{15} as 330 : 1. There is of course,

no reason why the present atomic weight standard O = 16 should be upset by this discovery, except that it becomes increasingly arbitrary. Raman spectra are treated only in the case of those diatomic molecules for which measurements are available (*e.g.*, H_2, O_2, N_2), and the results are correlated with the optical spectra. Most of the work done up to the present on Raman spectra deals with very much more complicated molecules and is outside the scope of this report. Chemists interested in this phase of the study of spectra have doubtless already made a note of Dr. Fox's discussion of the subject at the Chemical Society on February 16. A further point of some interest to chemists is the possibility of deriving the energy of dissociation of a molecule, and also its moment of inertia, from spectrum data. Finally, it should be mentioned that the report contains a large number of tabulated results relating to the band spectra of diatomic molecules, which serve as an excellent guide to the work already done. This subject is one which is developing very quickly, and indeed already embraces a number of triatomic molecules. Linked up with it, although not treated by Dr. Jevons, is the fundamental problem of valency and the nature and strength of chemical bonds. Few chemists at present would claim that our conception of these is entirely satisfactory, and it may well be that the contributions which physics is now making to the subject of molecular structure will modify many of our present theories. It is quite certain that many chemists will wish to familiarize themselves with some of this new physical work, and to them Dr. Jevons' report is to be heartily recommended.

Rubber History

It is only rarely, except in the more cataclysmic moments of world wars, revolutions, and the like, that one can be aware of history in the making. In the history of civilization indeed there seems to be no counterpart to the mutation of the biological world—that fresh start from which new things may develop. Instead civilization seems to grow gradually, sometimes stunted perhaps, and sometimes malformed, but generally with a healthy vigour. It does not do to carry the simile too far for growth has always been the forerunner of senility and decay, though it may be looked upon as cyclic and directed towards change and not an end-point. Rather perhaps do we keep on running along for ever like the brook that Tennyson set babbling years ago for all and sundry to hackney ever since. The history of chemical industry is of course being enacted every day, but in the peaceful babbling along we are perhaps prone to place more count on the passing of time than events, until we look back and realize that the moment has passed and history made while we were unaware. Yet such a moment of realization must surely have come to George Oenslager a quarter of a century ago when for the first time he used thiocarbanilide to "vitalize" the process of rubber vulcanization, whereby an operation taking hours was reduced to one of minutes and at the same time made more efficient. The practical application of his work, and its direct far-reaching effect on an established and growing industry were assured: he must then have known that the moment was something of a 1066 in the rubber industry. The two articles which we publish this week by George Oenslager and H. L. Trumbull are exceptionally interesting. Reading them is like climbing a circular staircase, watching each of the steps as they carry us upwards, whilst we wonder what is at the top. And yet the flights are somewhat spasmodically arranged, and the landings at times curiously protracted. It is strange to think that after Goodyear's discovery of the vulcanization process in 1839, using white lead and sulphur, "for some sixty years after . . . the industry was benefited by no important creative work." It may be that a demand for rubber products had not reached a high level before the commencement of the 20th century, and it required the demand for rubber tyres for these new-fangled motor-cars to show up necessity once more as the patient mother of invention. Yet there is probably a good deal behind the statement, as Mr. Trumbull has it, that "men were engaged primarily in reaping profits from the business made possible by the inventions of the pioneers." It places the industrialist in rather a sordid light, and one is tempted to moralize. But when, after the lull of sixty years and more, the quest for accelerators set in, the story becomes very fascinating. There was the direct financial success to be achieved, the scope of the operations, their secrecy, and even a spice of danger in handling some of the materials: the story needs only a platinum blonde in the background to make it altogether suitable for a Hollywood scenario. One can almost see the "talkie" so produced, with a bearded over-worked "professor" in imminent danger of being blown up by a colossal retort in a laboratory looking like a glass foundry, and guarding with his life a fateful "formula" calculated to deliver the goods. If we have been a little light-hearted let it not be imagined that it is in any way derogatory to the work of such pioneers as Oenslager. Such work could indeed have been undertaken by any competent chemist of good training and an experimental turn of mind, but it needed the resourcefulness and perseverance of an Oenslager to make it effective. That it was effective is now acknowledged, perhaps unconsciously, by every motorist who values the long life of his tyres: 8,000,000 lb. of organic accelerators are used yearly in America alone: one has only to read these two articles to realize the full import of the financial aspect of the work. The chemical industry too owes something to Oenslager for having demonstrated that it was "necessary to take the compounding of rubber out of the control of production superintendents and place it in the hands of chemists." The rubber industry has benefited by so doing, and is not alone. Many other industries have found it wise to raise the status of the technologist to that of a "technocrat," for "technocracy" is surely a little older than America would seem to imagine, even if our use of the word is a little different from that which seems suddenly to have been found for it. At all events the rubber manufacturing industry seems to have had its technocrats: it could not have reached its present state of development without them. Looking back, its stagnation of twenty-five years ago now seems almost incredible; but that is the way with history!

THE DEVELOPMENT OF ORGANIC ACCELERATORS FOR RUBBER VULCANIZATION

PERKIN MEDAL ADDRESS*

By GEORGE OENSLAGER

During my career as research chemist I have worked on many problems ; my efforts were sometimes successful but more often, I fear, productive of little that was of practical value. Whatever the results it has been my practice when the study of a problem was completed to dismiss it from my mind and give attention to new lines of work ; and so it was something of a surprise to me to learn that one particular line of research work which occupied my attention during my early days in the rubber industry had been considered by my fellow chemists to be worthy of special commendation—the work recognized in the award of the Perkin Medal. I shall endeavour to describe that work, which resulted in the industrial use of organic compounds as accelerators of vulcanization of rubber in the manufacture of rubber products, in such a way as to illustrate the value and importance of utilizing a scientific approach to an economic problem.

My entrance into the rubber industry 27 years ago was by arrangement with Mr. Arthur H. Marks, then general manager of the Diamond Rubber Company. I was assigned the problem of the economic utilization of low-grade rubbers. I was told the problem was difficult, and that I might work on it for six months or six years, or that I might even conclude the undertaking was beyond my powers. In any event I was assured that I would have a good time and learn a lot about rubber.

Twenty-five years ago all crude rubbers used were obtained from several types of plants growing wild in the tropical countries. Of these rubbers, the most important and most plentiful was that obtained from the tree *Hevea braziliensis* growing in the regions bordering the Amazon River and known in the markets as Fine Para rubber. Due to the care taken in its preparation and to its excellent physical properties after vulcanization it was, and in some respects is to-day, the world's premier rubber. The method of obtaining this rubber from the tree was as follows: A large number of V-shaped incisions about 4 in. long were cut in the tree with a light axe and at the apex of the cuts small cups were inserted under the bark to catch the milky latex which exuded. The latex, containing about one-third its weight of rubber suspended in water, was evaporated by pouring it slowly upon a paddle rotated over a smoky fire. In this way there was built up layer by layer a ball or biscuit of rubber weighing about 50 lb. Fine Para rubber thus prepared contained about 16% of water and was quite free from bark and other dirt. Another grade of rubber known as Coarse Para was composed of the small strips which had coagulated in the V-shaped cuts in the trees and of the masses coagulated from the latex by the fermentation which frequently occurred during the long slow process of forming the Fine Para biscuits. Rubber was also obtained in Central America from other genera of trees as well as from Hevea. One variety was produced by cutting down the tree, making incisions in the bark, collecting the latex and coagulating it by spontaneous fermentation or by the addition of the juice of acid-containing fruits. Another type known as Manicoba was prepared by making incisions in the tree and allowing the latex to evaporate spontaneously as it trickled down the trunk to the ground. In Africa rubber was procured almost exclusively from vines and giant creepers having diameters up to 6 in. As these vines did not lend themselves to tapping in the usual way, they were cut down and reduced to pieces of short length. The latex which exuded was either coagulated by boiling or by the addition of acid juices of fruits, or was simply allowed to flow upon the ground and evaporate. Practically all the wild rubbers available, with the exception of Fine Para, contained bark, sand, and varying amounts of moisture. Before use all grades were washed and dried, an operation involving a decrease in weight of between 18% and 50%.

The various types of rubber in the washed and dried state differed somewhat in toughness, either because of the presence of a large or small amount of resinous material or possibly because of differences in the degree of polymerization. But what was vastly more important they showed marked differences in quality after vulcanization. Up-River Fine Para and Manicoba rubbers, when vulcanized by heating after mixing with sulphur, gave products of the highest commercial value. This was not the case with most of the Central American and African rubbers, regardless of the amount of sulphur or the time and temperature of vulcanization. If, in addition to sulphur, there were added to the batch such materials as lime, magnesia, litharge, or white lead, which had been in use in the rubber industry since its earliest days for hastening the rate of vulcanization and improving the quality, Fine Para and a few other types of rubber still gave superior products. The difference in quality of the vulcanized product may best be illustrated by the following example. Into one lot each of Caucho rubber and Fine Para rubber were incorporated 10% of zinc oxide and 10% of sulphur. Sheets from these batches were vulcanized by heating at 287° F. during varying periods of time and their tensile strength, a most important criterion of quality, was determined. The mixture containing Fine Para developed a maximum tensile strength of about 3000 lb. per sq. in. when vulcanized 120 mins., whereas the Caucho mixture developed a maximum tensile strength of approximately 1900 lb. per sq. in. in 240 mins. Comparisons of Fine Para and Caucho rubbers in batches containing litharge likewise showed that the Fine Para gave a faster vulcanizing product having much higher tensile strength, than Caucho rubber. Caucho rubber, therefore, was considered a relatively slow-vulcanizing, or to use a more common term, a slow-curing rubber. The many commercial varieties of wild rubber differed greatly in their rates of cure and in the physical properties of the vulcanized products, none of them being equal to Fine Para. If, however, a slow-curing rubber developing a low tensile strength was mixed with a fast-curing rubber like Fine

* Given in New York before a joint meeting of the American Section of the Society of Chemical Industry, the American Chemical Society, the Société de Chimie Industrielle and the Electrochemical Society on January 6, 1933.

Para or Manicoba, the rate of cure and physical properties were intermediate in value. It was for this reason a matter of great importance that those responsible for the composition of the rubber batches twenty-five years ago should know the physical properties of each of the twenty or thirty types of rubber then available and blend them so as to secure the required physical properties in the manufactured goods. It was natural that these differences in the physical properties of the vulcanized products obtained from the different types of rubber should be reflected in market values of the crude rubbers.

Another rubber which at this point requires special mention is called Pontianac rubber. In 1899 and for fifteen years thereafter, the Diamond Rubber Company in Akron, Ohio, then one of the largest in this country, utilized a process for the extraction of rubber from the material called Pontianac or Jelutong obtained from trees growing in Borneo and Sumatra. It appeared on the market as biscuits weighing about 50 lb. It was white in colour, soft, and cheesy, and contained about 50% of water, 40% of resin, and 10% of rubber. After being converted into sheet form by passage between corrugated iron rolls it was agitated in a churn with successive portions of a mixture of acetone and naphtha in the ratio of approximately 55 : 45. The resin dissolved and the rubber settled out in the form of cement. After decantation of the resinous solution, the solvent in the rubber cement was driven off with steam. The resinous solution was separated into its components by distillation, and the distillates were again used as solvents. This process, devised by Mr. Marks while employed as chemist for the Diamond Rubber Company, yielded a commercial rubber at the comparatively low cost of fifty cents a pound. The peak production was fifteen tons per day. Because of its relatively poor quality after vulcanization, the extracted rubber was used by itself only in the manufacture of the cheaper grades of goods and was mixed in minor proportions with more expensive types of rubber for the production of higher quality goods.

Realizing that the physical properties of vulcanized rubber were determined by the type of crude rubber used in the mixture, Mr. Marks concluded that there must be some reason why Fine Para after vulcanization was much superior to any other type of rubber. He noted that of the two rubbers obtained from the same tree, Islands Fine Para by evaporation, and Islands Coarse by spontaneous coagulation of the latex, the Islands Fine was faster in cure and gave superior qualities after vulcanization. He also noted that Up-River Fine Para and Manicoba rubbers, both obtained by the evaporation of latex, were fast in their rate of vulcanization and gave high-grade vulcanized products. From this he reasoned that possibly during coagulation, as a result of fermentation, certain materials naturally occurring in the latex were either destroyed or were removed with the serum which separates during coagulation. These materials, perhaps small in amount, might be responsible for the superior quality of Fine Para. He therefore extracted the acetone-soluble constituents from some Fine Para rubber, amounting to about 2% by weight. The extracted rubber on being mixed with sulphur and vulcanized proved to be poorer in quality than the unextracted rubber. On adding the acetone-soluble material from Fine Para to a mixture containing Coarse Para and sulphur, the rate of cure was increased and the quality greatly improved. This fundamental experiment convinced him that perhaps the cheaper grades of rubber, and in particular rubber extracted from Pontianac, could be improved in quality after vulcanization by the addition to the crude rubber of materials then unknown. The problem of improving the quality of articles made from extracted Pontianac rubber was assigned to me as research chemist in 1905. The reward in case of success was most alluring. If it were possible to manufacture first quality goods from the ten-ton daily production of cheap rubber from Pontianac, there was a potential saving of around a dollar per pound of rubber—two thousand dollars a ton, or twenty thousand dollars a day.

The first question considered was: Does the extracted rubber have the same chemical composition as Fine Para? After freeing it from the 4% of organic dirt, 5% of mineral matter, and 5% of resinous material which it usually contained, the clean, transparent rubber, now of a pale yellow colour, had practically the same proportions of carbon, oxygen, and hydrogen as Fine Para rubber. Thinking that possibly the mastication of the extracted Pontianac rubber could result in partial oxidation, which might be the cause of its inferior qualities after vulcanization, systematic analyses of the rubber were made before and after mastication. No important change in chemical composition was found. Many other experiments were carried out in order to familiarize myself with the chemistry of rubber.

It was now thought desirable to carry out a systematic study of the effect of adding a great variety of typical inorganic compounds to simple mixtures of rubber, zinc oxide, and sulphur, and to note the results of heating for varying periods of time at different temperatures. In other words, endeavours were being made to find out whether or not there were catalysts of the reaction between rubber and sulphur other than white lead, litharge, lime, and magnesia, which had been in common use in the industry. It did not then seem reasonable to me that the oxides or hydroxides of three elements—calcium, magnesium, and lead—could be the only compounds which would act as catalysts for the vulcanization of rubber, a change which, in common with the chemists of that day, I attributed exclusively to a chemical combination between rubber and sulphur. It was my intention to experiment with at least one compound of all the commonly available elements and later with typical organic compounds.

The first compounding and curing experiments were conducted with materials then available in the laboratory. A suitable formula was chosen closely approximating that commonly used in the manufacture of tyre treads at that time, calling for 100 parts of Fine Para rubber, 62·5 parts of zinc oxide, and 6·2 parts of sulphur. Such a mixture developed its maximum tensile strength of about 2800 lb. per sq. in. when vulcanized 90 minutes at 287° F. In the

mixture the Fine Para was replaced with Corinto rubber, a Central American rubber which cured very slowly and had poor physical properties after vulcanization: and to it was added such materials as barium sulphide, zinc dust, aluminium powder, tin dust, lead powder, red phosphorus, antimony trisulphide, silver sulphide, mercuric sulphide, and many other materials. It was hoped that the added sulphides or, more probably, those formed in the rubber mixture by combination with sulphur under the conditions which obtained during vulcanization would further react to form polysulphides, and that these might be active catalysts or sulphur-carriers. All these materials, and many others, were found to be of little or no value as catalysts of the reaction. One material was found, however, which had remarkable properties, namely, mercuric iodide. When incorporated in small amounts into the standard rubber batch it had a profound effect on the rate of cure: for example, a mixture containing 100 parts of Corinto rubber, 60 parts of zinc oxide, and 10 parts of sulphur would not give a good technically cured product when heated for two hours at 291° F. The maximum tensile strength was only 1200 lb. per sq. in. When, however, 2½% of mercuric iodide, based on the weight of the rubber, was added to the batch, a product having a maximum tensile strength of 2600 lb. per sq. in. was obtained by vulcanization in the short time of 20 minutes. This substance was apparently a powerful catalyst for the rubber-sulphur reaction, and its effect on vulcanizing a number of the important grades of rubber was studied. The amount required to produce a definite degree of cure in a definite period of time at a definite temperature varied with the grade of the rubber, being smallest with the fast-curing and largest with the slow-curing rubbers. Even extracted Pontianac rubber, which gave a very poor technically cured product in a mixture containing only rubber, zinc oxide, and sulphur, gave, upon the addition of a small percentage of mercuric iodide, an excellent product closely approaching the highest grades of rubber in quality. After further experiments with mercurous and mercuric bromides and chlorides, mercuric iodide was found to be the most satisfactory material of all which were tried.

Here was a distinct step in advance. A substance had been found which, when added in small amount to any of the common rubbers, would cause them to cure under identical conditions, at the same rate, and yield products having approximately the same physical properties in the vulcanized state. Also, it was found that by decreasing the sulphur below the amount then in common use and increasing the amount of catalyst, the physical properties—tensile strength, for example—could be greatly improved. Mercuric iodide, therefore, not only hastened the vulcanization of the slow-curing rubbers, but also imparted to them in the vulcanized state the remarkably fine physical properties of high-grade rubbers, which litharge, lime, and magnesia had failed to do.

These experiments showed that tremendous profit could be made if through the use of mercuric iodide the cheaper grades of rubber could be substituted for the more expensive varieties. The fact was not overlooked that mercuric iodide might act as a carrier for oxygen as well as for sulphur, and consequently hasten the deterioration of the vulcanized product. However, lacking the laboratory ageing tests now commonly used for quickly measuring deterioration, the enormous economies at stake induced the company to manufacture in April, 1906, a limited number of solid and pneumatic tyres containing mercuric iodide and cheap grades of rubber in order to ascertain how they would perform in service. Because of over-cure or, more probably, because oxidation was promoted by the mercuric iodide, many of these pneumatic tyres failed badly in service. Nevertheless, the results of the work with mercuric iodide were very encouraging because they demonstrated that at least one material had been found which, when used in small quantities, would produce the desired effect on vulcanization. It was believed that only time and persistent experiments were required to find others. It was obvious that the poisonous characteristics of mercuric iodide made its use an extremely undesirable industrial hazard, and that something less injurious to workmen would have to be found. Therefore, without awaiting the results from the experimental tyres, and believing that the survey of the field of inorganic compounds had been sufficiently thorough for the time being, I turned my attention to organic compounds. When one considers that materials such as lime, litharge, and magnesia, long used as catalysts or accelerators for the reaction between rubber and sulphur, are basic in character, it would seem natural to conclude that an organic base completely soluble in rubber might be a more satisfactory catalyst. Aniline, being one of the simplest, commonest, and cheapest of the organic bases, was the first which I investigated. This material was found to have marked value as an accelerator when used in the tread recipe to the extent of between 4% and 6% of the weight of the rubber. Since the basic properties of aniline are due to the amino radical, it was deemed necessary to determine the significance of the amino group of organic compounds in their action as catalysts of vulcanization. Various nitrogenous bases were employed in the study. Toluidine and xylidine gave good results; naphthylamine in comparison gave poor results. Replacement of the hydrogen atoms of the amino groups with organic radicals seemed to decrease the catalytic action; dimethyl aniline and diphenylamine were found to be only slightly active, if at all. If to the amino group were attached a carbonyl group, as in acetamide or acetanilide, the activity was greatly decreased. Materials such as phenylhydrazine, containing an $-NHNH_2$ group, and hydrazo-benzol, containing an $-NH \cdot NH-$ group, were inactive. Quinoline gave fair results; urea gave excellent results, as did also hexamethylenetetramine. It was observed that not all compounds containing nitrogen were useful as accelerators, but of those which had value, the activity appeared to be related to the presence of amino nitrogen.

At the same time the search for good catalysts included various other types of compounds. Typical materials such as naphthalene and anthracene, iodoform and phenyliodide, mono- and di-nitro benzene, benzaldehyde, phenyl sulphocyanate, gallic acid, tannic

acid, phenol, ethyl oxalate, azobenzene, phthalimide—all were tested and found lacking in desirable properties as accelerators of vulcanization. Lead tetraethyl gave excellent results. It was later discovered that compounds containing the nitroso group were active. Nitrosodimethylaniline, for example, was found to be exceedingly powerful, much more so than aniline. When mixed with various wild rubbers in the standard tread recipe to the extent of about 0·5% it caused them to cure in about 15 minutes at 287° F., with the development of a maximum tensile strength of about 2800 lb. per sq. in. This looked like a remarkable accelerator and careful consideration was given to its adoption. There was one serious objection to it. When used in a rubber batch it stained yellow everything with which it came in contact. Even the hands of the workmen were coloured a rich yellow, a stain which was difficult to remove with soap and water. Hence this material was not considered as commercially desirable.

Attention was again turned to aniline, which seemed to offer fairly satisfactory possibilities as a commercial accelerator. It was cheap, but toxic when inhaled or brought in contact with the skin. Could it not be combined with some other material to form a solid body low in toxicity which preferably would melt at the temperature of vulcanization to form a liquid soluble in the rubber? It was hoped that such a material might be even more effective as an accelerator than aniline itself. The chemical having these desired properties was found to be thiocarbanilide, the reaction product of aniline with carbon disulphide. When it was mixed with various wild rubbers, zinc oxide, and sulphur, the rate of cure was greatly increased and the physical properties as evidenced by high tensile strength were remarkably good. Even the extracted Pontianac rubber, which when mixed with zinc oxide and sulphur would not give under any condition of vulcanization a product having high commercial value, responded strikingly to this accelerator. For example, if 3% of thiocarbanilide were added to the standard tread batch, a maximum tensile strength of 2500 lb. per sq. in. was developed on vulcanization for 60 minutes at 287° F. On doubling the amount of thiocarbanilide, the time of vulcanization was reduced to 10 minutes and a tensile strength of 3000 lb. per sq. in. was developed. The tremendous decrease in time of cure which was effected by the use of this accelerator gave promise of great commercial value, but of equal importance were the improvement in physical properties of rubber so vulcanized, and the more uniform behaviour of various grades of rubber when cured with this accelerator.

It now became necessary to choose the best chemical for experiments on a commercial scale. Such a material should be reasonably cheap, non-toxic, either a liquid or a solid easily reduced to a fine powder, reasonably powerful as an accelerator, and easily manufactured by employees with but limited intelligence. Thiocarbanilide seemed at that time to meet these requirements and accordingly a small plant was built for its manufacture. In September, 1906, this material and also aniline were employed experimentally in the manufacture of tyres. Thiocarbanilide was used as the accelerator in the tread portion of the tyre and aniline in the rubber compound which was calendered on the fabric.

In view of the unfavourable experience in the use of mercuric iodide, careful attention was given at this time to note any tendency toward rapid perishing on ageing resulting from the use of these two accelerators. Samples of vulcanized rubber containing varying amounts of accelerator and sulphur, cured for varying periods of time, were stored in the dark and were also exposed to the outside atmosphere for a period of nearly a year. Examinations were made periodically of the physical properties of these samples. At the same time, sections of tyres were stored away for ageing tests and were periodically examined. It became apparent that these two materials were not only accelerators of vulcanization, but also good preservatives of vulcanized rubber; in modern terms, they were fair anti-oxidants. Tyres were put into service in different parts of the country where they were exposed to varying climatic and road conditions. From time to time, as the promise of success became more apparent, larger and larger numbers of tyres were manufactured containing these two accelerators and the cheaper grades of rubber. Finally, in the latter part of 1907, aniline and thiocarbanilide were used in all the tyres manufactured by the Diamond Rubber Company, as well as in the bette[r] grades of solid tyres and mechanical goods. At tha[t] time my active interest in the discovery of new accelera[tors] ceased and henceforth I turned my attention to thei[r] manufacture and practical application.

The research work above described developed som[e] surprising results. The original purpose was to fin[d] some ingredient which would impart to rubber good[s] made from the cheaper grades of rubber the superi[or] wearing qualities then obtainable only from Fine Par[a]. While this was being accomplished it was discovered th[at] these same ingredients imparted to compositions mad[e] from the best grades of rubber a 20% increase in tensi[le] strength and a material reduction in the time of cur[e]. To-day, for example, some articles such as automobi[le] inner tubes are being cured in as short a period as seve[n] minutes; passenger car tyres which formerly require[d] three hours now require only a one-hour cure. Late[r] as a result of the growth and development of t[he] plantation industry, the price advantage of the wi[ld] rubbers was reversed in favour of the plantation grad[es]. There still remained, however, the technical advanta[ge] of improved physical properties and shorter periods [of] cure which resulted from the use of organic accelerat[ors] in rubber products.

The use of aniline and of thiocarbanilide, both in t[he] plant of the Diamond Rubber Company and of t[he] B. F. Goodrich Company following their merger [in] 1912, continued for some ten years. Aniline was fou[nd] especially desirable in the rubber compounds used [in] impregnating the fabric portions of pneumatic ty[res] because it made the uncured rubber soft and tac[ky] enabling it to penetrate thoroughly the meshes of [the] square woven fabric used in those days. In 1912 [the] Diamond Rubber Company largely replaced anil[ine] with para-aminodimethylaniline, after its supe[rior] qualities as an accelerator had been discovered by David Spence. Later, thiocarbanilide came to be u[sed]

extensively throughout the industry in the manufacture of mechanical goods, solid tyres, and the treads of pneumatic tyres. During its peak consumption it is probable that two thousand tons were used annually in the rubber factories throughout the world, and, although superseded by better accelerators, it is still used in small amounts. It will be appreciated that the early work here described was only the beginning of a great development in the use of organic accelerators. Since that time several hundred have been brought to light by many workers in various places and many of these are of special value in attaining specific results in the production of rubber goods. It is significant that most of these modern accelerators are derived from aniline.

A discovery of this kind could not long be kept secret in a great manufacturing centre like Akron. With the shifting of men from one factory to another it was but natural that comparisons of methods and materials should be made. In a short time it became known that certain chemicals were being put into rubber by the Diamond Rubber Company to make it cure faster and stronger. The information finally leaked out and in the course of a few years most of the factories in the Akron region were using chemicals such as aniline and thiocarbanilide in their rubber mixings. Realizing the value of the new line of thought brought out by the use of organic accelerators, several of the companies established research laboratories for the purpose of studying this and other problems relating to rubber. Later, discussions of the value of accelerators began to appear in the technical journals and the knowledge of their value spread far and wide. These facts illustrate the hopelessness of keeping a process secret under modern conditions, especially in a large factory.

It is generally believed that Gottlob and Hofmann were the pioneers of accelerator work in Europe. While engaged in the study of synthetic rubber they found that the rapid oxidation of that material could be greatly retarded by the addition of small amounts of organic bases. On vulcanizing synthetic rubber thus preserved they were astonished at its rapid rate of cure and its superior physical qualities. They then studied the effect of various organic bases on natural rubber also, and found that by the proper adjustment of the amounts of sulphur and bases it was possible to control the rate of cure almost at will and to secure a product having superior physical properties. Further study, which included a great variety of organic bases and their derivatives, led them to believe that any compound having a dissociation constant greater than 1×10^{-8} would have practical application in the vulcanization of rubber. Basing their claims on this dissociation constant, they secured a patent in Germany in 1914 and in the United States in 1915. This patent was declared invalid in the United States courts in 1926, both because the dissociation constant was an improper definition on which to base the claims and because of the fact that the use of organic accelerators had become common in the industry prior to Gottlob and Hofmann's discovery of their use.

One important outcome of the introduction of organic accelerators has been the realization that technically trained men are necessary in the rubber industry. Owing to the hazards of using highly reactive chemicals in the control of vulcanization without adequate knowledge as to their effects, it became necessary to take the compounding of rubber out of the control of production superintendents and place it in the hands of chemists. That step marked the passing of empirical methods. With the advent of the chemist into the industry came the examination and control of raw materials and the scientific study of the various stages of manufacture. In recognition of the value of applied science many corporations established and organized research laboratories for the chemical and physico-chemical study of rubber and of the various materials used in the industry. One of the most striking examples of their work is the modern development and widespread use of anti-oxidants. In contrast to the behaviour of catalysts which promote the combination of sulphur with rubber and other changes taking place during vulcanization, is the behaviour of materials which will retard the gradual combination of rubber with oxygen, to which is due the perishing of vulcanized rubber. Certain of these latter materials when added to the rubber batch to the extent of about 1% of the weight of the rubber also retard the cracking effect of repeated flexing and of sunlight on the finished goods.

Several large manufacturers of organic chemicals, realizing the importance of accelerators of vulcanization and of anti-oxidants, engaged in their manufacture—a business now amounting to about five thousand tons per annum, worth about five million dollars. In the interests of progress they, too, found it necessary to establish laboratories for the development of materials having specialized properties. These are now being sold to the trade with full information as to their advantageous use. Technically trained men, therefore, are now regarded as essential to the industry and will, let us hope, become a still more important factor in its growth and development. Perhaps you can realize the change which has taken place when I state that twenty-five years ago in Akron, which has become the world's greatest centre of rubber manufacture, I was one of the three chemists engaged in the industry. To-day when there is a meeting of the rubber technologists in Akron I am one of four hundred present.

THE IMPORTANCE OF ACCELERATORS IN THE MODERN RUBBER INDUSTRY*

By H. L. TRUMBULL

It is a privilege and a pleasure to recount some of the accomplishments of Mr. George Oenslager and to indicate the commercial importance of his work on organic accelerators. It is of particular interest to note that most modern organic accelerators are derived from aniline, and therefore have common parentage with the great galaxy of dyestuffs resulting from the work of Sir William H. Perkin, the original medallist. Since this is the first award of the Perkin medal to anyone connected with the rubber industry, it is appropriate to review briefly a few of the outstanding accomplishments in that industry.

* Delivered before the American Section and other societies on January 6, 1933, on the occasion of the presentation of the Perkin Medal to Mr. G. Oenslager.

Spanish explorers of the early sixteenth century found South American Indians playing with an elastic gum ball: 250 years elapsed with scarcely another recorded suggestion for the use of this strange gum. Joseph Priestley announced incidentally in 1770 that he had "seen a substance adapted to the purpose of wiping from paper the marks of a black lead pencil . . . . of singular use to those who practise drawing." From this use was derived the name "rubber." Some fifty years more ensued before the manufacture of rubber goods was actively undertaken. Crude footwear and rubber impregnated fabrics, it is true, had been made by South American natives from latex and exported to the United States and Europe. The resistance of these articles to water suggested the use of rubber in waterproof clothing and stimulated a widespread interest in rubber manufacture. In 1823 Charles Mackintosh, in England, discovered how to make double-texture clothing by spreading fabric with rubber solutions. Raincoats of this construction have ever since been known as "mackintoshes." At about the same time another pioneer, Thomas Hancock, started important developments which he continued for 30 years. He contributed fundamental advances, such as the mastication of rubber, the "pickle"—an internal mixing mill—and calender sheeting rolls, spread fabric with latex as well as with rubber cements, and in his factory he made rubber hose, bumpers, carriage tyres, and many other useful articles. He enlisted the aid of the great chemist, Michael Faraday, who established the empirical formula of rubber hydrocarbon. Hancock was a tireless worker, a true investigator who sought far and wide both information and materials to aid him in his task.

Other men in Europe and America, contemporary with Hancock, were trying to make clothing, footwear, mail bags, and other articles from rubber. Articles made by the new processes were however, disappointing, because they were sensitive to changes in temperature. In hot weather they became gummy and sticky, but when very cold turned as stiff as a board. The sensitivity to hot weather was much intensified in those articles made from masticated rubber, and these defects in the rubber goods of that time resulted in dissatisfied customers, even calling forth ridicule from Daniel Webster. Something had to be done to correct these imperfections.

It was Charles Goodyear who in 1839 made the discovery of vulcanization which insured the success of rubber goods manufacture. Goodyear observed that a mixture of rubber, white lead, and sulphur when heated gave a product not sensitive to seasonal changes in temperature. Although the substance essential to vulcanization was sulphur, Goodyear noted that mixtures containing both white lead and sulphur gave better results than those rubber batches which carried either ingredient singly. He was, therefore, also the discoverer of inorganic accelerators. A factory was started in Springfield, Massachusetts, in 1841, to carry out Goodyear's prosess, the foundation of all rubber goods manufacture. For some 60 years after the Goodyear discovery the industry was benefited by no important creative work. With the passing of the pioneers came an era of utilization. Some processes of handling rubber were perfected: many new articles were made: pigments such as lime, litharge, and magnesia were employed to advantage in shortening the time of vulcanization, performing essentially the same function as the white lead originally used by Goodyear: men were engaged primarily in reaping profits from the business made possible by the inventions of the pioneers.

At the beginning of the present century, crude rubber of high quality was not available in the quantities which prevail to-day, and the prices were high. Demands for more and more rubber goods were soon to come from the automotive industry. Reclaims made from scrap tyres, hose, etc. by the then new alkali process were replacing crude rubber to some extent, but only in low quality stocks. The supply of high grade crude rubbers was proving inadequate to meet the ever-increasing demand. In the face of this situation, perhaps no man was more keenly aware of the need for action than A. H. Marks, who in 1905 established a research laboratory and engaged George Oenslager as research chemist for The Diamond Rubber Company. The utilization of additional crude rubber was dependent upon the discovery of organic accelerators, but that is another story: suffice it to say that Mr. Marks had installed, and The Diamond Rubber Company was using, a process of extracting the rubber hydrocarbon from commercially neglected grades of crude rubber which were then available at relatively low cost.

As sole research chemist, Mr. Oenslager was entrusted with confidential information and great responsibility. A policy of secrecy prevailed. It is of interest to note that he had no chemist as an assistant. In the laboratory, however, was a man who had formerly operated a cheese factory: incidental to his other duties he served as a buffer to the idly curious, regaling them in plausible fashion with misleading information concerning the work in progress. At this time the need for results was urgent. After numerous laboratory attempts to derive high quality vulcanized compounds by adding various chemicals to the extracted low grade rubbers, Mr. Oenslager found that aniline gave excellent results. Soon after he made and tested thiocarbanilide, which is in many respects better than aniline. These chemicals, now called accelerators, were then termed "vitalizers," connoting their beneficial effect on low grade rubbers. Factory trials were promptly made, establishing the commercial value of this discovery.

Thus it became necessary for Mr. Oenslager to turn his attention to chemical engineering developments in the rubber industry. Early in his work he was asked to study the process in which rubbers such as Pontianac and Guayule were extracted with a mixture of acetone and gasoline. After removal of the supernatant resin solution by decantation, the solvents in the rubber cement were distilled off with steam. Many tons of both acetone and gasoline were used in the extractions, and solvent losses were high. In 1907 Mr. Oenslager, who abhors waste in any form, sought means to improve the process. Utilizing lubricating oil counter-current to gasoline vapours in a closed system, he devised one of the earliest absorption systems for gasoline vapour installed in this country, thereby originating the system

which since 1913 has become widespread in extracting gasoline from natural gas. By a similar method, with water in place of lubricating oil, he effected the recovery of acetone vapours. The resins from the supernatant liquid were recovered by steam distillation. Twenty thousand tons of waste Pontianac resin accumulated. Some of it was sold to paint and chewing gum manufacturers until Mr. Oenslager demonstrated its economic importance as a rubber softener in connexion with plantation rubber, whereupon it was utilized as an ingredient of rubber batches.

The first commercial use of organic accelerators, in 1906, was in conjunction with rubbers recovered from the extraction process. In that same year Mr. Oenslager started the first factory to produce the accelerator, thiocarbanilide. Production started in a rude shack of corrugated iron sheets held together with steel hooks so that in case of fire the hooks could be pulled and the roof would fall to smother and prevent the spreading of the flame. Steam coils next to the floor furnished heat to sheet metal tanks with oil-sealed covers. Carbon disulphide and aniline were allowed to react for five days. The product was spread upon a ventilating table to dry, after which it was ground in a ball mill. Those of you who have studied Gattermann's "Organic Preparations" will recognize that in avoiding admixture with alcohol and sodium hydroxide Mr. Oenslager departed from the accepted text book methods of the time. His reasons for this course were based upon his own preliminary experiments. This factory grew and eventually became a large unit with an annual production of 2,000,000 pounds of thiocarbanilide, at a cost as low as that of any unit in this country. Mr. Oenslager participated in every step of this development.

With the loss of foreign sources for aniline at the beginning of the war, it became necessary to build an aniline factory. Mr. Oenslager laid out and assisted in the building and operation of this plant, which was equipped with nitrators, reducers, and stills, and produced about 4000 lb. of aniline daily. Part of this product was converted into thiocarbanilide, and part of it was methylated to dimethylaniline and converted into *p*-aminodimethylaniline, an accelerator originated by Dr. David Spence. Waste acid from the nitrators, after boiling with ammoninm sulphate to decompose nitric acid, was utilized to remove the cotton from unvulcanized rubber scrap. The resulting product was used in rubber goods manufacture.

The incorporation of organic accelerators into rubber presented novel problems at every stage of manufacture. The more active accelerators caused scorching, or incipient vulcanization, on the mixing rolls and calenders. Hazards from toxicity had to be carefully considered in order to protect those who had contact with the stocks. The time and temperature of vulcanization had to be adjusted to the increased chemical activity of batches containing these organic catalysts. Secrecy prevailed and very few had knowledge either of the accelerators or of their properties. Mr. Oenslager had to be in close touch with those directing production operations to instruct men how to secure the best results with these new chemicals. Those who, for the first time, received from a trained scientist instructions for handling factory batches were impressed by his meticulous habits and exasperated by his insistence on careful adherence to details. They did not understand why he wanted to stand closely over batches giving off fumes which brought tears to his eyes, nor did they appreciate that this vigilance was necessary to the perfection of his important discovery.

The use of organic accelerators has made possible enormous improvement in the appearance and quality of rubber goods over those made according to the standards of 30 years ago. The surface bloom of sulphur which was then almost universal, is usually absent from modern rubber products. This produces a more pleasing appearance and permits a variety of bright or delicate colours. Improved conditions of vulcanization through the use of organic accelerators have made possible: (1) Products of high tensile strength, favoured by low temperature and short time of vulcanization. (2) Greater uniformity of physical properties throughout thick masses of rubber. (3) A more precise control of the product. (4) A wider range of physical properties, promoting a more extensive use of rubber articles. (5) Greatly retarded deterioration on ageing. (6) Improvement in resistance to deterioration at high temperatures. (7) The development of high-quality articles directly from latex. (8) Important economies in plant and equipment, resulting from shorter cures.

It was customary 30 years ago to vulcanize inner tubes for 90 minutes as contrasted with six to-day, and tyres for three hours as against less than an hour at the present time. The rubber industry represents a capital outlay of about $1,000,000,000. Organic accelerators have effected enormous savings in capital outlay as a result of the shorter curing periods and the more rapid turnover of equipment which their use has permitted. The saving in capital outlay for tyre and tube production in the United States alone has been estimated conservatively at $50,000,000.

Because of the commercial advantage of organic accelerators in the early days, it was not many years before other companies were also using these materials. Since that time hundreds of research chemists have laboured to effect improvements in their composition and in methods of use. These researches have resulted in the creation of a large new chemical industry. About 8,000,000 lb. of these organic catalysts are used in this country annually. In most chemical conversion processes catalysts are employed as contact masses and do not appear in the finished product. Organic accelerators, however, are catalysts which become a component part of finished rubber articles. This distinction explains the large tonnage of organic accelerators consumed in rubber manufacture. Though the original advantage of organic accelerators—to permit the use of cheaper, neglected grades of rubber—has long since disappeared, the use of these chemicals, for the reasons already mentioned, is firmly established in the industry.

Those who bought tyres 30 years ago and discarded them after 3000 miles of service appreciate the contrast with modern tyre performance. A significant part of the improvement in tyres must be credited to organic accelerators, although this credit is shared by many

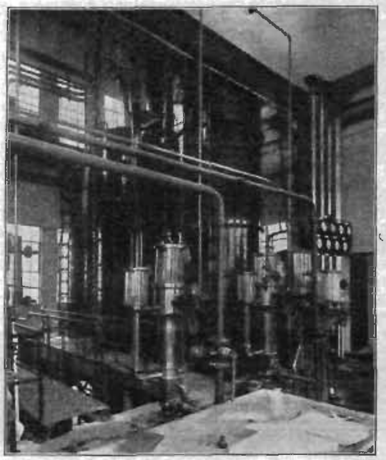
other developments. The saving to motor-car owners resulting from accelerators was estimated by Dr. W. C. Geer in 1924 at $50,000,000 annually. We now have twice as many motor cars as then, our tyres are much better and the mileage cost has been further reduced. There can be no question that tremendous economies have resulted from the use of organic accelerators, both to the manufacturer and to the consumer of rubber articles. Moreover, quite apart from economic considerations, organic accelerators have vastly enlarged the scope of our knowledge concerning that baffling hydrocarbon, rubber. Thus the discovery of organic accelerators can be rated second in importance only to that of vulcanization.

In recounting the contributions of Mr. Oenslager to the rapidly-growing rubber industry, I have indicated that his responsibility did not end when he synthesized and tested new materials as accelerators. A pioneer invention inevitably imposes a burden of necessary routine. If such work can be delegated to assistants, the burden is lightened and the programme is frequently advanced. Partly because of the company policy and partly because of his inherent caution Mr. Oenslager delegated very little responsibility to others. As a consequence he possesses a very wide and intimate knowledge of rubber technology, and even to-day he is not disposed to delegate much work to others. If he needs a carbon-hydrogen determination he will more often than not set up the apparatus and run the experiment. He prides himself on his training in quantitative analysis at Harvard under Prof. Richards.

In 1920, while retaining his connexion with the B. F. Goodrich Co., Mr. Oenslager went to Japan as technical adviser to the Yokohama Rubber Co., where he remained for two years. While there he had an opportunity to utilize the fruits of his previous experimentation and to prove to his own satisfaction the commercial value of accelerators in rubber products. He returned by way of Java, Sumatra, and Malaya, where he spent several months in intensive study of rubber plantations. Upon his arrival in Akron he resumed his research career. His more recent accomplishments have resulted from studies of the chemistry of vulcanization, and have been reflected in specific improvements in such diverse lines as tyres and rubber tank linings for severe chemical service. He is modest, almost to the point of reticence, and is reluctant to admit that his accomplishments have resulted from his own ability, inclining to the view that he has done only what another chemist would have done had he been afforded the same opportunity. His modesty and his simplicity have endeared him to his friends. He works on a regular time schedule, and finds time outside of working hours to engage in many public-spirited enterprises. He has travelled extensively in all parts of the United States and from Alaska to Bermuda and is an idealist who thoughtfully engages in a variety of interesting activities. Pride in good work, independence of thought, and an almost ascetic self-discipline have always characterized him and are responsible in no small measure for his accomplishments.

SOLVENT PRODUCTS, LTD.

In a recent article in this JOURNAL we directed some attention to the "silent workers" of modern chemical industry—the name given by Dr. Armstrong to the indefatigable and noiseless agencies by which many and vast quantities of industrial products are made. The silent workers are not of course associated with every chemical works, but if we should have had any doubts as to their importance, these would have been quickly dispelled in a visit we recently paid to the works of Solvent Products, Ltd., at Dagenham Dock, Essex. Although huge quantities of sugar were being converted every moment to alcohol, there was little to indicate the fact beyond the movement here and there



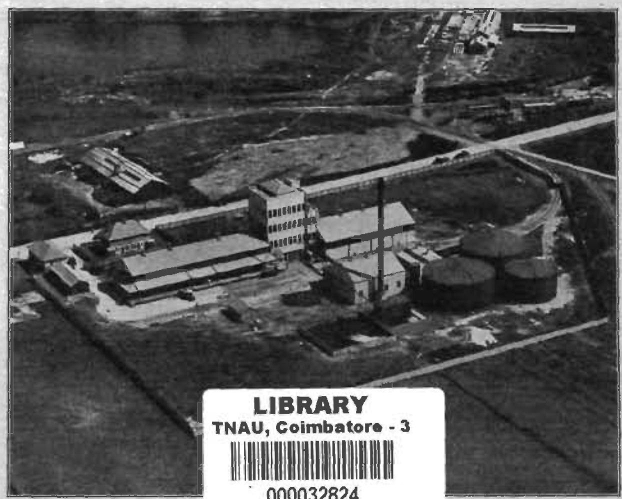
Still and operating platform

of a needle on a gauge, or the syphoning of a clear liquid in a glass column. The word factory has until now been associated with bustle and noise, crowds, smoke, and machinery in action; the works of Solvent Products, Ltd. did much to impress us with the fact that the word is losing a good deal of this significance.

Solvent Products, Ltd. is concerned with the production of industrial alcohol, using molasses as the raw material. It is one of the youngest firms in the chemical industry, having been formed in 1927, but it is an important unit where fermentation is concerned, and its equipment is up-to-date and laid out in an exemplary manner. Molasses are brought to Dagenham Dock in tank steamers, and from the wharf on the riverside are conveyed by pipe lines to the factory, entering the huge storage tanks that can be seen in the accompanying aerial photograph. The molasses are diluted with water and conveyed to the main fermentation building,

where there is a battery of 12 tanks, each with a capacity of 55,000 gallons. In the meantime cultures of yeast are prepared for the fermentation process: starting with an agar "slope" of the desired species of *Saccharomyces*, successive incubations are carried out in the laboratory with the addition of nutrient material, until two gallons of the culture have been prepared, taking about 24 hours. This culture is taken into the factory, where it is mixed with molasses, and built up in three fermenting stages, taking 12 hours each, until 3000 gallons are obtained, the yeast culture then being ready for introduction into one of the 55,000-gallon fermenting tanks. At first sight these tanks appear to be threaded together with a tangle of pipe lines, for separate pipes are necessary for the conveyance of the diluted molasses, the yeast culture, the "wash" after fermentation, additional nutrient material—this being ammonium sulphate and sulphuric acid, added to ensure the presence of the necessary mineral matter for the yeast development—and the carbon dioxide evolved in the fermentation.

The whole process proceeds automatically to a time-table, the necessary sterilizing precautions being taken with all the vessels employed to make sure that no development of undesirable fungi or bacteria occurs. The fermented wash, obtained about a week after the incubation of the original yeast, needs only to have the alcohol separated from the molasses residues and other impurities, and this is effected in long columnar patent stills. The wash enters at the top and is made to trickle slowly downwards in the column, meeting steam coming in the opposite direction which heats it, carrying the alcohol upwards as vapour, the bulk of the water and molasses residues falling to the bottom of the column. The alcohol so obtained is diluted again and further purified by subjection to a similar process, after which it is rectified, or concentrated to about 95%—96% by condensation. Part of this rectified spirit is taken a stage further to absolute alcohol, used in a number of industrial processes and in the preparation of power spirit, but the bulk of the spirit, amounting to about 50,000 bulk gallons per week, is taken to storage tanks for ultimate sale in this form, or for treatment prior to sale as methylated or denatured spirit. Throughout the whole of the process of manufacture a strict surveillance is exercised by customs officials, and it was rather strange to see so many parts of the plant sealed with padlocks—a complication with which only a few chemical manufacturers have to deal.



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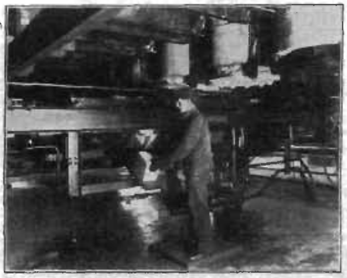
Aerial view of distillery

The principal by-product of the fermentation is carbon dioxide, some 150 tons a week being evolved when the battery of 12 tanks is in full operation. How to deal with this economically has until recently been something of a problem, but one which has now been solved by the application of "dry ice," or solid carbon dioxide, as a refrigerant. During the last year the company has erected a plant for the solidification of carbon dioxide by the process of the Esslingen Maschinenfabrik of Germany, the main feature of which is to submit the gas to pressure of about 60 atmospheres at a temperature of about 15° C. The gas, as it comes from the fermentation building, contains small quantities of alcohol, aldehydes, and other substances which have to be removed before the process of solidification is operated,

and the gas is therefore first compressed to about three atmospheres pressure, and then passed through a series of scrubbing towers. The first of these scrubs the gas with a water spray, removing the bulk of the impurities, and the second contains calcium chloride to remove the bulk of the moisture in the gas. The gas then passes through several towers containing sulphuric acid for the removal of all traces of water and some organic impurities, through a heavy gas oil to remove acid, and finally through charcoal to absorb any remaining organic impurities.

The purified gas is then passed through a 3-stage compressor, providing successively pressures of 7, 20, and finally 60/70 atmospheres. Considerable heat is developed during each compression, and at the completion of each the gas is taken through a cooling system of pipes over which water at 15° C. is running. The liquid carbon dioxide which is produced by the final compression is then introduced into the top of a high tower, the sudden return to atmospheric pressure causing about 50% of the liquid to solidify in the form of a



"Dry ice"—Base of towers and presses

"snow" which drops down in the tower, the remaining 50% being given off as gas, which is collected and used again. At the bottom of the tower the snow falls into a steel cylinder in which it is subjected to the action of a hydraulic ram exerting a pressure of 2000 lb. per sq. in. This compression packs the snow into solid blocks of "dry ice," which are ejected from the bottom of the tower ready for transport, either in large quantities, for which cork-lined chests are employed, or in small packages, in which case containers of corrugated cardboard in several thicknesses are employed.

This material has already established a market for itself in the production and keeping of ice cream, and its great suitability has been demonstrated for the freezing of fish and the refrigeration of other perishable goods in transport. Its great advantage is that it does not cause deterioration of packages by wetting, since loss is occasioned by direct evaporation; this loss is also small, being only about 20% in 24 hours. There would seem to be every possibility of its finding a number of applications in the future, providing yet another example of the endeavour to find an outlet for a by-product leading to the setting up of an important industry.

SOCIETY OF CHEMICAL INDUSTRY

OFFICIAL NOTICES

British Industries Fair. The Society's stand at the London Fair (February 20—March 3) is again situated in the Chemical Section, Olympia, and is numbered A14. A universal charge of 2s. for admission will be made this year and no free tickets are available.

It is hoped members will make use of the facilities provided on the stand, including telephone.

The General Secretary will be pleased to forward on application vouchers entitling members visiting either or both Fairs at London or Birmingham to reduced railway fares.

New Members. Correction to list published on January 20: for Deacon (Bradford Corporation Electricity Department) read JARVIS, William Deacon.

FOOD GROUP

In contributing to the discussion on "Factory Cleanliness in the Food Industry," at the joint meeting of the Food Group of the Society and the Royal Sanitary Institute, on January 20 (Cf. CHEM. & IND., Jan. 27, pp. 75—78), Dr. T. Carnwath, D.S.O., M.B., Senior Medical Officer, Ministry of Health, said:

The feeding of the people of these islands, most of whom are town dwellers, is a very complex problem and, of necessity, canned and prepared foods form an important and valuable part of the food supply of the nation. That illness of one sort or another should occasionally result from their use, as it does from other forms of food, is not to be wondered at: the remarkable fact is not that accidents should occasionally occur, but that they occur so rarely. Examples of gross carelessness are happily infrequent; nevertheless, it is necessary for those who have responsibility in this matter, either as manufacturers or public health authorities, to exercise constant care and vigilance.

Mr. Hughes has mentioned the possibility of contamination with heavy metals from the use of unsuitable equipment or packing materials. Risks to health from this source should be constantly borne in mind by manufacturers, and every effort made, as far as possible, to eliminate them.

On the biological side there is always the risk of pathogenic organisms finding their way into prepared foods, from the use of contaminated raw materials, from faulty methods of manufacture, or from unintelligent handling. It is possible to devise an elaborate and impressive technique which may be of great value commercially in preventing deterioration and in ensuring the uniformity of the product which, nevertheless, fails to prevent pathogenic infection. It is interesting to recall that in the Loch Maree outbreak, for example, in which eight persons died as the result of eating wild duck paste infected with *B. botulinus*, the paste was prepared in one of the best-equipped and best-managed factories in London. The most important group of food poisoning bacteria is the salmonella group. These are very widely distributed in nature. They are found as a natural infection in certain animals, the flesh of which is used for human food. One or other strain

can be isolated regularly from sewage effluents, from which we may infer that they are almost constantly present in a community. This emphasizes the importance of attention to the human element in the factory. *The only practicable method of controlling this risk* is first careful selection and adequate medical supervision of the workers, and, secondly, strict cleanliness of person and clothing, which means easily accessible facilities for washing, suitable clean overalls, and intelligent co-operation of everyone engaged in the work.

A great deal of work is now being done on the effect of fumigants on various food parasites, but I think it is important to see that these fumigants are not used as substitutes for cleanly methods.

Twenty-five or 30 years ago health officers had the greatest difficulty in convincing food manufacturers of the importance of cleanliness, and constant care was required to ensure even a minimum of attention being paid to the matter. Now the tables are almost turned; this meeting affords evidence of the interest now being taken by manufacturers in this question of cleanliness. This is all to the good. It is to the manufacturers, I think, that we must look for further progress. The health officer desires safety, but he has not always the technical experience to tell the manufacturer how the objective can best and most economically be achieved, and that is where the manufacturer can help.

Continuing the discussion, Mr. A. Andersen, *of* Unilever, Ltd., said:

I intend to confine myself to certain aspects of factory cleanliness which may be considered supplementary to the previous remarks of other speakers. My example is from the butter and margarine industry, in which cleanliness is of the utmost importance, as some of the raw materials and the finished product are of a perishable nature, and the use of preservatives is prohibited; further, the product cannot during, or at the end of the manufacture, be sterilized. Utmost cleanliness is therefore necessary for the preservation of these foods to make them keep sufficiently long to meet the requirements of the trade and the consumer. Preservation is, however, largely a biological question and the bacteriologist is therefore a more valuable helper in controlling cleanliness than the chemist. The object of cleanliness is to *prevent impurities getting into the product.* I am not dealing with the obvious and easily visible impurities, but with those which are hardly visible or invisible, which can either be sterile, and therefore may be called chemical impurities, or they can consist of micro-organisms and are then generally called infections.

Whereas intelligent supervisors and well-trained workpeople can and will deal with the obvious impurities scientifically trained men are required to deal with the latter.

Impurities can get into the factory in various ways: they can gain access through the raw materials. The regular examination by the well-known methods of all deliveries of milk shows the impurities that get in in that way, and also gives a picture of the degree of cleanliness with which the milk has been treated and handled before arrival. Fatty raw materials are not generally carriers of impurities; *most of them are sterilized* in course of the refining process. Animal fats rendered at low temperature and packed and transported in barrels should, however, not be ignored. Salt although generally *considered a sterile preserving material is not* always free from impurities. Packing materials, labels, wrappers, etc., which cannot be washed before use should not be stored in places where dust is allowed to settle peacefully. Some of these packing materials come in direct contact with the surface of a perishable food, and impurities find an excellent medium for growth. The water supply is at times a source of impurities and even if the original supply from wells or mains is satisfactory, deterioration may take place in intermediate storage tanks and in pipelines.

Air is another and very frequent source of introduction of impurities, and the manufacturer of a perishable food is up against great difficulties here. Even so-called pure air contains a considerable number of micro-organisms which in many cases find an excellent medium for development on the foodstuff. Where these organisms come from is in many cases difficult to detect. Information about them is obtained in the well-known manner by exposing a suitable nutritive medium in a petri dish to the air for a time which is determined by experience and may be anything from 10 minutes to 1 hour. Incubation of the petri dishes generally takes 4 to 5 days, but they are, of course, examined periodically during that time. Daily examination in every department may not be required, but where it can be done it is advisable to have the air in the room where food is exposed examined daily. Regular tests on these lines will give information about the contamination which may be caused from the air, and will soon show if something abnormal is taking place. It should be mentioned that if any micro-organisms are particularly harmful to the product a special search is made for them by suitable composition of the medium, and temperature of incubation.

As regards impurities from plant, tools and utensils, these may be introduced by the foodstuff or deposited from air or water. Certain impurities arising from corrosion of metals are outside the scope of my survey, although they are in the dairy industry of considerable importance, and more and more attention is given to them owing to their catalytic effect on the fats, and *it is a point which is growing in importance in view of* the tendency to use metal instead of wood in construction of the plant; metals have many advantages from the point of view of cleanliness, as by suitable cleaning they can be kept practically sterile, but corrosion and abrasion may introduce factors which will give the chemist plenty to do. Whereas it is fairly easy to keep metal surfaces clean and practically sterile, wood constitutes a permanent source of danger, and it is extremely important that examination of wooden surfaces is undertaken regularly. Other sources of dirt and impurities in food are accumulations on floors, walls, ceilings, girders, etc., but this point has already been dealt with by previous speakers.

To determine whether impurities have got into a product, and if so where, regular examination of the product must be made. Samples should therefore be taken in as great a number as conditions allow, both of the finished product and from the different stages during

manufacture, and the picture of the microbial flora, as given on the nutritive media, will show to which extent impurities from the various sources may have gained access to the food and found a suitable place of development.

You will note that although I have principally dealt with microbial impurities, I have not referred to the use of the microscope. This is obviously used when it is desirable to obtain more information about the various types of organisms, but for a routine control the macroscopical examination by the methods described makes it possible to carry out many more tests: you can easily examine 2 to 300 samples daily in that way, but this would be a considerable strain if examined by the microscope. Further, the appearance of the colonies on the medium, their action on the medium and their action on various indicator dyes give, as a rule, sufficient information for routine purposes. With a knowledge of the sources of infection and type of infection a basis is created for systematic cleaning, and in describing certain points in connexion with this, I will once more emphasize that these apply specially to the dairy and margarine industry. It is not possible to prevent impurities from entering the factory where raw materials are, such as milk and other highly-perishable non-preserved products, where water has to be used, and where the foodstuff is at some time or other exposed to the air. Cleaning comes in to eliminate the impurities as far as possible, and to render them harmless. Where milk as a raw material is used for manufacturing purposes, and where pasteurization will not make it less suitable, this process has been resorted to as in that way many impurities are prevented from getting further than the pasteurization plant. The well-known methods for removing mechanical impurities in milk and incidentally through that process also a large number of micro-organisms are highly recommended. The water available should be of high purity. Storage tanks should be cleaned periodically, sediment removed and cleaning finished with a suitable disinfectant, for which purpose mopping down of sides, top and bottom with a hypochlorite solution has proved very effective. This solution can be left on for as long time as available, and all traces are easily removed by swilling down with a supply of fresh water and any accumulated microbial growth is killed off.

As regards the air, many factories must rely on the quality as natural ventilation provides it. Where food is exposed it is frequently found an advantage to supply the factory with purified air and suitable plants are on the market. I am not in this connexion referring to plants which will purify and sterilize small quantities of air, but to those which will deal with large quantities, for instance, at the rate of a million cu. ft. per hour. Filtration has frequently been suggested, but in my experience has not proved satisfactory, the filtering material soon forms a breeding ground for micro-organisms and after a time the air instead of being purified becomes richer in organism. Washing by passing the air through a spray of finely-divided water and overwet scrubber plates followed by a removal of water drops by means of eliminator or baffle plates purifies the air to a considerable extent, a very considerable reduction in the number of organisms being attained when the plant is used and supervised in the proper way: as much as 90% of the organisms has been frequently eliminated. The water can be kept practically sterile if an addition of hypochlorite is made, for instance, to the extent of 0·25%. Many tests have shown that if this concentration is maintained, the water keeps sterile and the number of organisms passing the water screen is very small.

Probably the most serious source of impurities is the plant, owing to the continual contact with a perishable product, and to deposition of impurities from the air. Extreme cleanliness of plant is therefore essential, and is obtainable only by correct cleaning assisted by correct construction. As regards the personnel, dressing rooms should be provided in which they can exchange their outer garments for factory clothing of light washable material. The lighter the material the easier dirt is seen. These clothes can be thoroughly washed so that all traces of decomposable foodstuff are removed and they should be well dried: it should not be overlooked that if clothing is damp and smeared with a little of the food which may get on during working operations, it can be quite a nest of micro-organisms before many hours. Beware particularly in damp factories of heavy canvas clothing and oilskins, sometimes provided as protection for workers at wet processes. These materials frequently get thoroughly permeated with moisture and food remnants, and are difficult to keep clean. Workers applying for employment should be medically examined before being employed in a food factory, and regular supervision during the work should be maintained; hand inspection of employees coming in direct contact with the food should be part of the regular duties of the supervisor.

My remarks have dealt with the routine control of cleanliness, but in course of this work problems sometimes arise the solution of which can only be given after a good deal of research work, but the application of this to factory cleanliness falls outside the scope of these remarks.

In the following contribution to the discussion, Sir Weldon Dalrymple-Champneys, M.D., Medical Officer, Ministry of Health, said that after the excellent and comprehensive paper by Mr. Hughes and the interesting contributions of subsequent speakers, only the wide extent of the subject and its innumerable ramifications made it possible for him to add anything to the discussion. Mr. Hughes had said that "in cleaning utensils and containers . . . the aim should be sterilization wherever possible." With this view the speaker heartily agreed, but he thought it was important to retain a sense of proportion in this regard. The highest practicable degree of cleanliness should be aimed at, but absolute bacteriological sterilization was seldom possible. Even in the operating theatre with all the aseptic ritual usually employed, the operation wound probably did not remain sterile for a minute. Sterilization was in fact a relative term. Cleanliness was a matter of custom, which differed widely in different countries. With regard to the constant maintenance of cleanliness

in a food factory Sir Weldon suggested that this could not be secured merely by an efficient cleansing routine, even if this was combined with regular personal supervision, the importance of which had been rightly emphasised by Mr. Hughes. It was necessary in addition that the personnel should have an intelligent understanding of the principles involved and the aim in view, and should be really keen on attaining this end, if accidents were to be avoided. Sir Weldon's extensive experience of factories where therapeutic substances such as sera, vaccines, etc., were made had impressed upon him the fact that without intelligent co-operation of the staff, any ritual of cleanliness might become a real danger by breeding a false sense of security. The speaker also emphasized the importance of detail in the cleansing of apparatus, such as pipe lines. He often found in inspecting pasteurizing plants that almost magical virtues were ascribed to the use of a wire brush followed by steaming, but the brush was apt to be kept whilst not in use on the floor or on a dusty shelf or beam, and the duration of the steaming was indefinite and often quite inadequate.

There was a popular belief that bad food looked, tasted or smelt bad, but usually this was not the case. The food consumed in the outbreaks of botulism in this country, for instance, had seemed to the consumers to be excellent in every way, but had nevertheless been dangerously infected. This fact increased the responsibility of the manufacturer, as did also the increasing sophistication of food.

Dr. T. W. Naylor Barlow (Medical Officer of Health, Wallasey) said he would like to emphasize two points which had been made by previous speakers. The first was that the factory was only one link in the chain, and food might be contaminated before it reached and after it left the factory. The second point was that though much attention had been devoted to the actual building, perhaps the most likely source of contamination was the individual handling of foodstuffs inside the building. Under no circumstances should the workers be lost sight of in this connexion. He thought that sometimes in discussing a question like this one we were in danger of losing our sense of proportion. With regard to sterilisation, one speaker actually referred to sterile air entering the factory, as if a factory were an operating theatre. He pointed out that there was a very great difference between micro-organisms getting into the blood stream from a cut and the organisms getting into the system via the intestinal tract. Judging from the infrequency of food-poisoning cases and the unsatisfactory condition of very many places where food is prepared, the digestive processes must be a tremendous safeguard. We should remember also that a very small proportion of the food is prepared in factories. In the provision of clean food the necessary step was the registration of all places where food was prepared. One could do nothing unless one knew where these places were, and he reminded the audience that the Medical Officer of Health, who was the person mainly responsible for food cleanliness, had even more limited powers in factories than he had in ordinary work places. He was of opinion that all food should be labelled and the date of the manufacture displayed on the label, and it should be illegal for that label to be removed, and the label of another firm substituted for it, as is often done. People should know the date when the food they were eating was prepared.

A contribution to the discussion was also made by Mr. A. L. Bacharach, who agreed with the emphasis previous speakers had placed upon the proper utilization of utensils, plant, and materials. He urged that this should be made humanly possible by giving the operatives, and especially those in the more responsible positions, at least an elementary technical understanding of the processes they were working, and the principles underlying their technical control.

PLASTICS GROUP

An extra meeting confined to members of the Group was held at Burlington House on Friday, January 20, for the purpose of discussing the future policy of the Group and also to sound the views of members on the character of the Group's exhibits and participation in the forthcoming Exhibition of Plastics at the Science Museum.

The meeting and subsequent informal dinner, under Mr. H. V. Potter's chairmanship, was conducted in a very friendly atmosphere and the free exchange of views should prove of the utmost value to the executive in framing its future programmes.

It is hoped shortly to announce full particulars of this first comprehensive exhibition of plastics which is to open early in April.

SOUTH WALES SECTION

An ordinary meeting of the South Wales section of the Society was held jointly with the local section of the Institute of Chemistry at Thomas's Café, Swansea, on Friday, January 20, when a lecture was given by Prof. J. E. Coates, of the Swansea University, on " Some Recent Advances in Physical Chemistry." The chair was occupied by Mr. C. M. W. Grieb.

After referring briefly to some of the main directions of progress in recent years, the lecturer adopted for more detailed treatment the subject of the rate of chemical reactions, confining himself to gaseous systems on account of their relative simplicity.

Different types of reaction were discussed from the point of view of the kinetic theory of gases, and the importance in this field of recent advances in our knowledge of molecular structure was indicated. In this connexion the lecturer referred to the promising attempts which have recently been made to apply modern physical theory to chemistry.

During the discussion the hope was expressed that another lecture on similar lines would be given in the near future, and Prof. Coates was warmly thanked.

BRITISH CHEMICAL PLANT MANUFACTURERS' ASSOCIATION

The Annual Dinner of this Association was held on Thursday, the 26th January, at Jules Restaurant, Jermyn Street. Mr. E. A. Alliott presided and many men well known in the chemical industry were present as guests or otherwise, including Dr. E. F. Armstrong,

chairman of the Association of British Chemical Manufacturers, Mr. J. Piggott, manager of the British Steel Export Association, Mr. T. Nightingale, managing director of Sheffield Steel Products, Ltd., Dr. R. H. Pickard, president of the Society of Chemical Industry, Mr. A. W. Cremer, honorary secretary of the Institution of Chemical Engineers, Mr. F. A. Greene, honorary treasurer of the Institution of Chemical Engineers, Mr. J. Arthur Reavell, chairman of the Chemical Engineering Group, Mr. D. McDonald, honorary secretary of the Group, Mr. J. Kewley, president of the Institution of Petroleum Technologists, Mr. D. A. Bremner, director of the British Engineers' Association, Mr. D. Hutchinson, one of the senior officials of the Import Duties Advisory Committee, Prof. W. E. Gibbs, Mr. S. G. M. Ure, and Mr. Leo Ryan of Mallincrodts Chemical Works, Canada.

Mr. Alliott, after the loyal toasts, made an introduction to a valuable discussion on the possibilities of co-operative selling in overseas markets. He explained that the Ottawa Conference had revived an interest in the problem and that many people felt that in such countries as Canada, with the intensive competition to be encountered from the United States, it would not be possible for this country to obtain the maximum benefit from the preferences secured at Ottawa unless the various sections of industry got together to organize co-operative effort. The discussion was continued by Dr. Armstrong who described the attitude of the Canadians as expressed in his conversations with them in Canada last autumn; he pointed out the difficulties in overseas selling at the present time and explained the measures to be taken to overcome such difficulties. Mr. Julian Piggott and Mr. Nightingale followed and showed how co-operation could secure good salesmen abroad and proper arrangements for prompt delivery of spare parts and proper technical assistance for customers. These two speakers showed actual results that had been obtained by such efforts and how quickly an important addition to British sales had been brought about by taking pains and tackling the problem in a business-like way. The discussion was continued by many other speakers and was both interesting and suggestive. Among those who attended the dinner in addition to those already mentioned were Messrs. F. C. Arnold, S. G. Beard, N. G. Bland, C. P. Braby, H. J. Bush, A. C. Cross, S. Dickson, R. M. Drake, E. F. Evenden, W. R. Gordon, H. A. S. Gothard, W. H. Hatfield, G. N. Hodson, J. Hopcraft, H. W. James, W. S. Knight, A. E. Knowles, R. Lessing, C. Mann, F. May, J. H. G. Monypenny, B. F. Pinnegar, H. J. Pooley, J. Davidson Pratt, J. H. Randall, E. A. Reavell, W. Russell, R. Seligman, C. J. Seaman, R. Sims, F. M. H. Taylor, G. H. Whitham, E. Williamson, J. W. Wilson, R. Worssam, and the editors of CHEMISTRY AND INDUSTRY, *The Chemical Age*, *The Engineer*, and *Engineering*.

MANGANESE IN CANADA

The Dominion Department of Mines at Ottawa has recently issued a report by Dr. George Hanson on manganese deposits in Canada, giving particulars of the occurrence of manganese ore in each of the Provinces. The known deposits are confined chiefly to the Maritime Provinces and British Columbia.

INSTITUTION OF CHEMICAL ENGINEERS

A large attendance, under the chairmanship of Mr. J. Heron Rogers, met at Burlington House on January 25, to have further expounded by the authors three papers on Sewage Disposal which had been printed and circulated in advance.

The authors, Messrs. H. C. Whitehead and F. R. O'Shaughnessy, Mr. L. R. Howson and Dr. Karl Imhoff, the leading authorities in England, America and Germany respectively, supplemented their papers by explanatory talks illustrated by many lantern slides. Owing to the exhaustive length of the others it is only possible to publish Dr. Imhoff's paper in this issue. The British paper deals historically with most of the known systems used here tracing the conception, development, and perfection of each in considerable detail. The American treatise is more mechanically detailed and is profusely illustrated.

Dr. Imhoff, whose paper is brief, atoned by a fascinating description of the Ruhr sewage problem with its systematic use and re-use of the purified effluent and the courageous system of dams now nearing completion designed to quadruple the length of the natural aëration system in which the procedure depends.

A large number of those present took part in the subsequent discussion.

German Practice in Sewage Disposal

By Karl Imhoff, Dr.-Ing.

Almost all towns in Germany are provided with sewage purification works, but the degree of purification attained is less than in England because Germany possesses larger rivers.

Screening plants.—These are provided in the case of about 59 large and medium size towns, such as Ruhrverband, Dresden, Düsseldorf, Hamburg, Karlsruhe, Cologne, Magdeburg, Kiel, situated on the larger rivers and embracing a population of about 5½ millions. New screening plant is now only rarely installed since it only accomplishes very little in comparison with the cost.

Grit chambers or detritus tanks.—Grit chambers and detritus tanks form part of nearly all sewage purification plants into which storm water gains access. They are constructed and operated in such a manner that they yield clean sand as far as possible. Grit chambers are either narrow and of small cross-section, so that the velocity through them is sufficient to keep the grit clean, or the grit which settles in them is cleaned by means of air-blowing or washing.

Septic tanks.—Septic tanks preceding bacteria beds are to be found in 25 towns such as Aix-la-Chapelle with 400,000 inhabitants. Such tanks are not regarded as complete purification works, but they are commonly adopted in private houses. In German towns some 1½ million inhabitants are still connected to such small septic tanks for individual houses.

Settling tanks.—Such tanks are very prevalent in German installations. Their design is based upon questions of sludge disposal. For the last 25 years settling tanks have been built so that smell is eliminated; the sludge has been digested under water and then dried on the land. In connexion with settlement and sludge digestion it is necessary to distinguish between

two-storey tanks, in which the upper portion is devoted to settlement and the lower portion to sludge digestion, and those in which sludge digestion is accomplished in separate sludge digestion tanks.

Two-storey tanks are the more numerous; they have been adopted in 240 towns, and works like Emschergenossenschaft, Ruhrverband, Berlin-Wassmannsdorf, Danzig, Halle, Erfurt, Görlitz, Hindenburg, Pforzheim, Rostock, Stuttgart, Nürnberg, with a population of 5½ millions.

Separate sludge digestion tanks have been adopted in 70 towns with a population of 2 millions, such as Berlin-Stahnsdorf, Nürnberg, Hildesheim, Quedlinburg, Stuttgart, and in the works of the Emschergenossenschaft and of the Ruhrverband. In these separate sludge digestion installations the settling tanks are mostly of the hopper-bottom or Dortmund type. More recently tanks provided with special sludge scrapers have been adopted, especially at larger works. Many types of machinery have proved suitable in this respect.

Well-digested sludge has been obtained in separate digestion tanks only within the last few years since heat has been applied to the tanks. More recently new installations, especially in large towns, are being constructed rather on the separate digestion principle than on the two-storey tank principle, because it is not possible to heat two-storey tanks. The temperature of separate digestion tanks is maintained between 70 and 80° F.

Agreement has now been reached among the majority of works operators with regard to the advantage of mixing the fresh and fully digested sludge in the digestion tanks. In heated tanks complete mixing as soon as the fresh sludge is introduced and a continual mixing of the whole mass are both regarded as unnecessary. In unheated tanks some advantage may be obtained by the various systems of mixing. Mixing can, however, never replace heating.

With large digestion tanks provision is generally made for gas recovery. A gas recovery of 460 litres per kilogram of dry organic matter in the sludge, that is, 14 litres of gas per head per day, can be reckoned with in the case of ordinary settling tanks, and double this amount with activated sludge plants in which the excess activated sludge is discharged either directly or indirectly into the digestion tanks. This quantity of gas is sufficient for providing the necessary heat and power for operating an activated sludge plant.

Sewage farms.—These are very common in Germany. The sewage of a population of 6½ millions in 45 towns, such as Berlin, Bielefeld, Bremen, Breslau, Danzig, Darmstadt, Dortmund, Freiburg, Königsberg, Münster, is discharged to sewage farms. The sandy soil of the North German Plateau lends itself very well for irrigation purposes. The purification attained is very good, but in many places complaints of smell are common. Most irrigation farms are over-loaded, and in many towns artificial purification works are being constructed to give preliminary treatment and to relieve the irrigation areas.

Trickling or percolating filters.—Trickling or percolating filters have been adopted by 90 towns like Aix-la-Chapelle, Beuthen, Bielefeld, Gleiwitz, Hildesheim, Halberstadt, Stuttgart, Remscheid, with a population of 1,300,000. The effluents are good in some cases, but complaints with regard to smell and the fly nuisance are being made. Contact beds are used in 17 towns, comprising Brieg, Gotha, Merseburg, etc., with a population of 200,000, but are no longer being installed.

Activated sludge plants.—Plants of this type are in use in 13 towns, such as Berlin-Stahnsdorf, Erfurt, and in the works of the Ruhrverband, with a total population of 900,000. Such plants have a promising future and technically are to be preferred to percolating filters. In most cases compressed air is used for aëration, either alone or in combination with mechanical plant, to produce surface aëration. Efforts are being made to effect purification by maintaining as small a quantity as possible of activated sludge in the aëration tanks.

The excess activated sludge produced in the process is usually pumped back to the primary settling tanks, but in order to do this it must be possible to remove the sludge from these tanks automatically and continuously. Examples of such tanks are Dortmund tanks, two-storey tanks, or tanks provided with scrapers which are in continuous operation. If the excess activated sludge is dealt with in this way the sludge digestion tanks must be three times as large, because the sludge is doubled and contains much more water. The sludge drying beds must be quadrupled. The yield of gas is doubled.

Fish ponds.—As a final stage in the process of sewage purification fish ponds are used in 12 cases—for example, Munich, Amberg—for a population of 1 million. The effluents are excellent in character. The area of the ponds is not more than 1/10th of that required for sewage farms to deal with the same quantity of sewage.

Impounding reservoirs or artificial lakes.—These have been constructed in the Ruhr district with the object of purifying polluted river water. The Ruhrverband has constructed three such reservoirs, with a total surface of 1400 acres in the stretch of the river Ruhr from which drinking water is obtained. The process of purification is biological self-purification, which is artificially increased by the increased time of flow and the extended water surface. These lakes contribute as much to the purification of the river Ruhr water as the whole of the 70 artificial sewage treatment plants in the area. They do not cost anything, as the interest on the expended capital is covered by the income derived from the developed water power.

On the whole the technique of sewage purification in Germany in recent years has moved towards the mechanical side. This is historically interesting, because before the war developments were in the reverse direction. When 50 years ago sewage purification was introduced into Germany from England, with the exception of sewage farms the artificial processes introduced comprised chemical precipitation and machinery of every description. For sludge disposal, filter presses, centrifugal machines, and incinerators were introduced. In the course of time these artificial processes were displaced almost entirely by natural processes such as bacteria beds, sludge digestion tanks, two-storey tanks, and sludge drying beds, which were emptied by

means of hand labour. In the more recent installations a return has been made to mechanical operation, especially since the introduction of the activated sludge process of sewage treatment. Sludge scrapers in settling tanks and rotating arms and circulating pumps in sludge digestion tanks have also been introduced. Mechanical sludge filters and other methods for artificially drying sludge have again awakened interest. It may be that this development is the most suitable for large towns of, say, 1 million inhabitants, but for small and medium size towns it does not seem advisable to depart unnecessarily from the natural methods of purification. In other directions, also, it has become clear that it is not always a good thing to displace hand labour by means of machinery; natural processes should be allowed to maintain their proper significance.

CORRESPONDENCE

EUROPEAN GRAPHITE COMPANIES

SIR,—In your issue of January 27, under "Personal," you refer to the fusion of certain German graphite companies, and conclude with the statement that the new company, namely Graphitwerk Kropfmuhl, "will thus become the ONLY German graphite company."

We feel it necessary to point out that this statement is incorrect. The fact is that quite apart from the company in question there are other active and important German graphite companies.

We hope that you will be able to give publicity to this correction.

Thanking you for your courtesy,

We are, Sir, etc.,
BUSH, BEACH & GENT, LTD.
(Signed) K. WILLIAMS,
Director

London, E.C.3
Jan. 27, 1933

PERSONAL AND OTHER ITEMS

We are much pleased to hear of the honour accorded to Mr. F. A. Greene, M.I.Mech., M.I.E.E., M.I.Struct.E., by his appointment as Fellow of King's College, London University. Mr. Greene is well known to many members of the Society and is at present a member of council of the Society and honorary treasurer of the Chemical Engineering Group.

It is announced that Prof. J. B. S. Haldane has resigned the Sir William Dunn Readership in Biochemistry in the University of Cambridge. Although no official announcement is as yet forthcoming it is believed that Prof. Haldane is leaving Cambridge to take up an appointment at London University.

Prof. F. W. Aston, of Cambridge University, and Prof. Robinson, of Oxford University are amongst a number of prominent chemists in Europe who have been invited to Chicago to address various scientific groups, either on the occasion of the American Chemical Society's annual meeting in October, or at the meeting of the American Association for the Advancement of Science in June.

The title of Reader in Experimental Physiology in the University of London has been conferred on Mr. H. P. Gilding, M.A., B.M., in respect of his post at University College.

Prof. L. N. G. Filon, C.B.E., F.R.S., Goldsmid Professor of Applied Mathematics and Mechanics in the University of London (University College), has been elected vice-chancellor of the University for the remainder of the academic year 1932—33 in succession to the late Mr. Hatton.

Mr. M. G. Evans, M.Sc., has been appointed Assistant Lecturer in Chemistry in the University of Manchester as from next September.

We regret to record the death on January 12 of Dr. William F. Edwards, director of research of the United States Testing Company. Dr. Edwards was professor of chemistry in the University of Washington from 1895 to 1897, and served as president of the University from 1897 to 1900. He was a member of a number of scientific societies in America.

Mr. Wilfred Smith, of Dumbartonshire and Glasgow, manufacturing chemist, left estate in Great Britain of gross value £53,000, with net personalty £52,674.

A Frankland Memorial Association

If present plans materialize Lancaster will become the home of a body which will have as its object the perpetuation of the memory of Sir Edward Frankland. Although Frankland was not born in Lancaster he came to the borough at a very early age, and received his education and much of his early training there. On January 18, the anniversary of Frankland's birth in 1825, a meeting was held in the Storey Institute, Manchester, presided over by Mr. W. French, and an address was given by Prof. H. E. Armstrong, who studied and worked with Frankland many years ago.

British Chemical Plant Manufacturers' Association

The Official Directory of this Association grows in volume of directory and in volume of advertisements. In such a volume the latter are an essential feature of permanent value. The new chairman, Mr. E. A. Alliott, the new vice-chairman, Mr. J. W. Wright, the new honorary treasurer, Mr. W. S. Knight, and the new honorary auditor, Dr. H. J. Bush, have long been prominently identified with the important industry of chemical plant manufacture and they are assisted by a thoroughly representative committee. Several firms have joined the Association since the last directory was issued: Messrs. Fredk. Braby & Co., Ltd., W. P. Butterfield, Ltd., English Steel Corporation, Ltd., Hathern Station Brick & Terra Cotta Co., Ltd., R. Marsh & Co., Newton, Chambers & Co., Ltd., and Turner Bros. Asbestos Co., Ltd. Four thousand copies of the directory have been circulated, and every buyer of chemical plant ought to make use of this directory.

New Lead Vein Discovery

Testing operations are at present being carried out by the Weardale Lead Co. on a new vein that has recently been discovered in the isolated hills of Upper Weardale. The first indications are satisfactory, and it is believed that the vein is a rich one running through the Weardale Hills for many miles.

Cold Temperature Laboratory Tests

An interesting cold temperature laboratory investigation was recently carried out when the cameras which are to be used in the flight over Mount Everest were tested in an atmosphere at — 40° F. at the works of J. & E. Hall, Ltd., the refrigerating engineers, Dartford. The cameras worked at this temperature without a hitch, and the lenses did not cloud over, whilst the rolls of sensitized films did not, as had been thought possible, become so brittle at this temperature as to break.

Liquefaction of Helium

A process for the liquefaction of helium that is claimed to be more simple and rapid than those hitherto employed was recently operated by Dr. F. A. Lindemann in connexion with his research work on the effect of low temperatures. The apparatus for the work was brought over from Breslau University, and it is stated that a successful endeavour was made to get down to a temperature of 2° absolute.

Textile Institute

Sir William Clare Lees, who is managing director of the Bleachers' Association, has been nominated for the office of president of the Textile Institute in succession to Mr. George Garnett. The election will take place on May 17 at the annual meeting.

The annual conference of the Institute is to be held this year from June 7 to 10, when a number of papers on the subject of textile finishing will be preseuted.

Canadian Mining

Lake Shore Mines, Ltd., the leading gold producer in the Kirkland Lake district, northern Ontario, is now erecting a metallurgical plant for the reclaiming of gold values remaiuing in the tailings dumped during the past few years in the bed of Kirkland Lake. Gold production is expected to reach $500,000 annually. Tailings of both the Wright-Hargreaves and Lake Shore mines have been dumped for several years in the east bay of Kirkland Lake, and are understood to aggregate four million tons.

The International Nickel Company, Ltd., intend to reopen at Copper Cliff, Ontario, the Orford process plant trausferred late in 1931 from Port Colborne, Ontario. The resumption of operations will provide part-time employment for 300 men, and sufficient blister copper will be produced to meet the requirements of the Ontario Refining Company, Ltd. (an associated company), which is transferring consignments of electrolytic copper to Great Britain. The Orford process represents the first stage in separating copper-nickel matte into copper "tops" and nickel "bottoms."

A new electric steel furnace has recently been installed by Sorel Steel Foundries, Ltd., at Sorel, Quebec, requiring approximately 1000 electric h.p. for operation. The company manufactures manganese, carbon and other steel alloys for mining and general industrial use.

A marked increase in the use of coke in Canada during the past few years has resulted in the erection of several new coking plants. With this new construction the producing capacity of Canadian plants is now sufficient to meet the ordinary demands of the country for coke fuels.

International Aluminium Competition

In 1932 an international competition was instituted by world producers of aluminium on the lines of previous competitions with the object of awarding prizes for the best suggestions made relative to the use of aluminium and its alloys. The two principal awards of 4,000 Swiss francs each have been voted to Dr. Eckert of Germany for his researches on the protection of aluminium and its alloys and to M. Phillippe of Paris, for his memorandum on the use of aluminium alloys in gas and oil-fired central heating plaut. Other awards, bringing the total to 20,000 Swiss francs, have been made to Mr. Y. Hirakawa of Japan, Herr. T. Scheizer of Switzerland, M. Py of France, Herr Steinborn of Luxembourg, and M. H. Tatu of France. The Bureau Internationale de l'Alumiuium received 405 memoranda in connexion with the competition, most of them being based on serious investigations.

William Gardner & Sons, Ltd.

A firm which is passing successfully through the period of trade depression is William Garduer & Sons, Ltd., the well-known Gloucester manufacturers of sifting, mixing, and grinding machinery. At a recent dinner at which the employees of the firm were entertained by the directors, Mr. Charles Gardner said that orders obtained from a large number of countries had kept the works goiug at full capacity.

American Chemical Society

The eighty-fifth meeting of the American Chemical Society is to be held from March 26 to April 1 in Washington. The meeting is to include a public address by Dr. Irving Langmuir, who recently received the Nobel Prize for chemistry, the subject of his address being "Surface Chemistry."

Chemical Production in U.S.A.

According to a preliminary compilation of information by the American Bureau of Census the total value of chemicals manufactured in the United States during 1931 was $190,617,673. Some of the major items contributing to this total were pyroxlin plastics valued at $11,113,618, phenolic resins $8,057,620, refined glycerin $10,299,482, electric-furnace ferro-alloys $13,210,665, stannic chloride $5,743,308, and monobasic calcium phosphate $5,060,977.

Chandler Medal Award

The Chandler Medal for 1933 is to be awarded to Dr. G. O. Curme, vice-president and director of research of the Carbide and Carbon Chemicals Corporation of America, in recognition of his outstanding work on aliphatic compounds. The medal was instituted in 1910 in memory of Prof. C. F. Chandler, one of the founders of the American Chemical Society, and previous recipients of the medal have included Prof. F. Gowland Hopkins, Dr. Leo H. Baekeland, Dr. Irving Langmuir, and Dr. W. R. Whitney.

A Correction

In last week's issue, page 74, col. 2, par. 3, the word "phosphates" has been omitted from the first line. The sentence should read "In the manufacture of ammonium phosphates by this process" etc.

REVIEWS

THE TERPENES. By Prof. J. L. Simonsen, D.Sc., F.I.C., F.R.S. Vol. II. Dicyclic Terpenes, Sesquiterpenes and their Derivatives. Pp. xi + 627. Cambridge: University Press, 1932. 35s.

This volume completes Prof. Simonsen's monograph on the terpenes. It is considerably longer than the first volume on monocyclic terpenes and is written on the same basis, each chapter being devoted to the derivatives of a single structural terpene unit in the following order, hydrocarbons, alcohols, ketones. This unity of treatment makes the book easy to read and facilitates ready reference. The protean changes possible in the molecule of pinane require 118 pages for their description and camphane is even more exigeant with 204 pages, of which no less than 120 are concerned with camphor, whilst the newer and so far less versatile carane can be disposed of in 22 pages. The treatment of each section is as clear as a thorough grasp of the subject, elimination of irrelevant details and careful writing can make it: graphic formulæ are supplied in abundance and are drawn and arranged to make the points they are designed to illustrate obvious at a glance, a matter upon which many authors are much less considerate of the reader. The last section of the book dealing with sesquiterpenes is perhaps the most interesting if only for the reason that it is in this branch of terpene chemistry that new methods of attacking constitutional problems are being rapidly developed and applied, not only to the sesquiterpenes themselves and to their immediate derivatives, but also to groups of naturally-occurring substances whose biological relationship to the terpenes has only recently become apparent.

Both volumes are well produced; errors and omissions are few and the indexes, of which the reviewer has made considerable use in the case of the first volume, cover all reasonable needs. The author is to be congratulated on this satisfactory completion of what must have been an extremely arduous task. T. A. H.

FOOD PREPARATION STUDIES. By A. M. Child, K. B. Niles, and A. Kolshorn. Pp. vi + 156. New York: J. Wiley & Sons: London: Chapman & Hall, 1932. 10s. 6d.

This manual is arranged in the form of studies and sections. The studies deal in turn with the functions of the principal foods in the diet, suggest typical dishes to be prepared, and indicate the sections to which reference should be made for an explanation of the principles involved in the methods of preparation.

The sections give a summary of the chief properties of the principal food constituents—carbohydrates, proteins, etc. This is followed in each case by a tabulated list of facts and principles which underlie the methods and processes used in the preparation and cooking of foods containing these constituents. Blank spaces are left opposite each rule and principle for the student to fill in the applications when the practical work indicated in the studies has been completed. Definite recipes for the suggested dishes are not given, though the authors have in another publication, "Food Recipes," compiled recipes suitable for use in conjunction with the manual.

The demand for books of this type intended for use not only as text books but also as note books for recording individual observations or results is generally somewhat limited. The authors having planned the book with their own scheme of work in mind are likely to be able to make much more effective use of the book than other teachers; the latter should however find the book of value as providing an outline of one method of approach which might be used in attempting to deal with the principles and methods underlying the preparation and cooking of food. H. M.

COMPANY NEWS

GAS LIGHT & COKE CO., LTD.

The company has announced that the accounts for 1932 show a balance of net revenue enabling the directors to recommend payment of the half-yearly dividends on the 4% consolidated preference, the 6% redeemable preference, and the 3½% maximum stock, in addition to a final ordinary payment of 2½%, which brings the total dividend on ordinary stock to 5½%: £215,550 remains to be carried forward as against £139,121 last year after transference of £40,000 to redemption fund.

SOUTH METROPOLITAN GAS CO.

The text has been made available of a Bill which the South Metropolitan Gas Co. is promoting next session in an endeavour to obtain relief from the present enactments relating to gas companies, by which all additional ordinary or preference stock is required to be issued by public auction or tender. It is stated that this method of issuing capital has not been found conducive to raising money on the most advantageous terms, and new provisions are sought to enable the company to issue stock at any price and in any manner decided upon by the directors.

The ordinary stock of the company totals £6,709,895, and the directors have recommended a final dividend of 6% per annum, less the interim dividend of 2½% paid last September. This dividend is at the same rate as last year.

DISTILLERS CO., LTD.

The directors announce an interim dividend of 7½% less tax on the ordinary shares.

MONSOL, LTD.

It is announced that Monsol, Ltd. has been registered as a private company with Lord Melchett and Sir Robert L. Mond as directors.

MIDLAND BANK, LTD.

The Ordinary General Meeting of the Midland Bank, Ltd. was held on January 27, 1933. The chairman, the Right Hon. R. McKenna, said in the course of his speech, that conditions were distinctly better than a year ago, notwithstanding the persistence of a deplorably high level of unemployment. Our national finances were sounder; a marked reduction had been made in the balance of imports over exports; the volume of

business had been fairly maintained: new industries had been established; and, though exchange and other restrictions were stifling trade with foreign countries, there were signs of steady development of inter-Imperial trade.

This unmistakable improvement at home had certainly not been helped by events abroad. The hopes arising from the Lausanne Conference had vanished in the face of disappointment regarding the war debts to America. Political uncertainty in many countries had clouded the prospect of recovery, and the gloom of trade depression had shown no sign of lifting. The impoverished debtor countries, one after another, had all but closed their doors against imports. In these circumstances it was the more remarkable that this country, deeply involved as it was in international trade and investment, should have shown any improvement at all.

We had experience now of sterling divorced from gold for over sixteen months, and nothing catastrophic had happened. Almost everyone now recognized that a rise in primary commodity prices was essential to world recovery. Controlled inflation, from being the remedy of fools or knaves, had become widely regarded as the best available solution of our troubles, particularly since it has become realized that a substantial rise in wholesale prices need have no more than slight effect upon the cost of living. There was nothing in recent experience to give ground for discouragement or scepticism regarding the benefits to be derived from an expansive monetary policy. We were free to regulate in great measure our own price level by increasing or diminishing the quantity of money. But we should not allow ourselves to be disturbed by the fact that if gold continued to appreciate while our price level remained steady or rose the inevitable effect would be a fall in our exchange.

Dealing with the position and progress of the bank, Mr. McKenna commented on the lower level of advances, pointing out that the decline was evidence of the restricted field for accommodation to industry and trade.

Between the end of 1929 and June 30, 1932, advances fell by £23½ millions. Of this sum, a little more than one-half had to be accounted for under the general heading of accommodation to industry and trade. When the detailed figures were examined it became clear that the decline in business advances was not traceable to undue pressure on the smaller borrower, but to shrinkage in the demand. Advances to agriculture, for example, which numbered more than 18,000, were actually higher by nearly 5% than at the end of 1929.

The downward movement in the total amount was readily explained by two main tendencies: temporary accommodation had been largely replaced either by new issues of capital or debentures or by fixed, long-term loans from insurance companies, savings banks and similar institutions, whilst the rise in prices of gilt-edged securities, more especially since the end of 1931, had induced many trade borrowers to realize investments for the purpose of repaying in part or in whole, their obligations to the bank.

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned.

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

GENERAL HEAVY CHEMICALS

Acid, Acetic, 40% tech.—£20 5s. per ton d/d address U.K. *in casks.*

Acid, Chromic.—11d. per lb., less 2½% d/d U.K.

Acid, Hydrochloric.—Spot, 3s. 9d.—6s. per carboy d/d according to purity, strength, and locality.

Acid, Nitric 80° Tw.—Spot, £18—£20 per ton makers' works, according to district and quality.

Acid, Sulphuric.—Average National prices f.o.r. makers' works, with slight variations up and down owing to local considerations: 140° Tw., Crude Acid, 60s. per ton. 168° Tw., Arsenical, £5 10s. per ton. 168° Tw., Non-arsenical, £6 15s. per ton.

Ammonia (Anhydrous).—Spot, 10d. per lb. d/d in cylinders.

Ammonium Bichromate.—8d. per lb., d/d U.K.

Bisulphite of Lime.—£6 10s. per ton f.o.r. London, packages free.

Bleaching Powder, 35/37%.—Spot, £8 15s. per ton d/d station in casks, special terms for contracts.

Borax, Commercial.—Granulated, £15 10s. per ton; Powder, £17 per ton. (For 1-ton lots and upwards, packed in 1-cwt. bags, carriage paid any station in Great Britain.)

Calcium Chloride, Solid, 70/75%.—Spot, £5 5s.—£5 15s. per ton d/d station in drums.

Chrometan.—Crystals, 3⅝d. per lb.; Liquor, £19 10s. per ton d/d U.K.

Chromium Oxide.—10d.—10½d. per lb., according to quantity, d/d U.K.

Methylated Spirits, 61 O.P.—Industrial, 1s. 8d.—2s. 3d. per gal.; Pyridinized Industrial, 1s. 10d.—2s. 5d. per gal.; Mineralized, 2s. 9d.—3s. 3d. per gal. 64 O.P. 1d. extra in all cases. Prices according to quantity.

Nickel Sulphate.—£53 per ton d/d.

Nickel Ammon. Sulphate.—£53 per ton d/d.

Potash, Caustic.—£30—£33 per ton. Potass. Bichromate crystals and granular.—5d. per lb., net d/d U.K., for spot. Discount according to quantity. Ground 5⅝d. per lb. Potass. Chlorate.—3¾d. per lb. ex whf. Lond. in cwt. kegs.

Potassium Chromate.—6½d. per lb., d/d U.K.

Sal ammoniac, Firsts lump.—Spot, £42 17s. 6d. per ton d/d address in barrels. Chloride of Ammonia.—£37—£45 per ton, carr. paid.

Salt Cake, unground.—Spot, £3 15s. per ton d/d station in bulk.

Soda Ash, 58° E.—Spot, £6 per ton, f.o.r. in bags, special terms for contracts.

Soda, Caustic, solid 76/77° E.—Spot, £14 10s. per ton d/d station in drums, special terms for contracts.

Soda crystals.—Spot, £5—£5 5s. per ton d/d station or ex depôt in 2-cwt. bags.

Sod. Acetate 97/98%.—£21 per ton. Sod. Bicarbonate (refined).—Spot, £10 10s. per ton d/d station in bags. Sod. Bichromate Crystals, Cake, and Powder.—4d. per lb., net d/d U.K., discount according to quantity. Anhydrous 5d. per lb. Sod. Bisulphite Powder 60/62%.—£16 10s. per ton delivered, 1-cwt. iron drums for home trade.

Sodium Chromate.—3⅞d. per lb., d/d U.K.

Sod. Phosphate.—*£13 per ton, f.o.r. London, casks free.* Sod. Silicate 140° Tw.—Spot, £8 5s. per ton d/d station returnable drums. Sod. Sulphate *(Glauber's Salt).*—Spot, £4 2s. 6d. per ton d/d. *Sod. Sulphide solid, 60/62%.*—Spot, £10 15s. per ton, d/d in drums. Crystals, 30/32%.—Spot, £8 per ton, d/d in casks. Sod. Sulphite, Pea Cryst.—Spot, £13 10s. per ton, d/d station in kegs; Commercial.—Spot, £9 10s. per ton, d/d station in bags.

RUBBER CHEMICALS

Antimony Sulphide.—Golden.—6½d.—1s. 1½d. per lb. according to quality. Crimson.—1s. 3d.—1s. 5d. per lb., according to quality.

Arsenic Sulphide, Yellow.—*1s. 6d.*—*1s. 8d. per lb.*

Barytes.—£7 10s.—£9 per ton, according to quality.

Cadmium Sulphide.—3s. 1d.—3s. 5d. per lb.

Carbon Bisulphide.—£30—£32 per ton, according to quantity, drums extra.

Carbon Black.—3¾d.—5¼d. per lb., ex wharf.

Carbon Tetrachloride.—£40—£45 per ton, according to quantity, drums extra.

Chromium Oxide, Green.—1s. 2d. per lb.

Diphenylguanidine.—2s. 4d. per lb.

India-rubber Substitutes, White.—4¼d.—4¾d. per lb. *Dark.*—3½d.—4¼d. per lb.

Lamp Black.—£46—£50 per ton.

Lead Hyposulphite.—9d. per lb.

Lithopone, 30%.—£18—£19 per ton.

Mineral Rubber "Rupron."—£18 10s. per ton.

Piperidine Rubber Accelerators.—P.P.D.—10s. 6d.—11s. 6d per lb.; Z.P.D.—7s.—7s. 6d. per lb.; L.P.D.—6s. 6d.—7s. per lb.; P.T.D.—9s. 8d.—10s. 4d. per lb.; C.P.D.—8s. 3d.—8s. 10d. per lb.; S.P.D.—8s. 1d.—8s. 7d. per lb.; P.T.M.—11s. 6d.—12s. 6d. per lb.

Sulphur.—£12 per ton. Sulphur Precip. B.P.—£55—£60 per ton. Sulphur Precip. Comm.—£50—£55 per ton.

Sulphur Chloride.—*5d.*—*7d. per lb., according to quantity.*

Vermilion, pale or deep.—4s. 6d.—4s. 11d. per lb.

Zinc Sulphide.—1s. 1d.—1s. 2d. per lb., according to quality.

WOOD DISTILLATION PRODUCTS

Acetate of Lime.—Brown, £8 10s.—£8 15s. per ton. Grey, £10 10s.—£12 per ton. Liquor, Brown, 30° Tw., 6d. per gal.

Acetic Acid, technical, 40%.—£16 10s.—£18 per ton.

Amyl Acetate, technical.—95s.—110s. per cwt.

Charcoal.—£6—£11 per ton, according to grade and locality.

Methyl Acetone, 40/50%.—£50—£52 per ton.

Wood Naphtha.—Miscible.—2s. 7d.—4s. per gal. Solvent, 3s. 9d.—4s. 9d. per gal.

Wood Tar.—£2—£6 per ton.

Wood Creosote.—6d.—2s. per gal.

TAR PRODUCTS

Acid Carbolic.—Crystals.—9d.—11d. per lb. Crude *60's, 1s. 11d.*—*2s., 2% water, 2s. 5d. per gal.*

Acid Cresylic, 99/100.—1s. 7d.—1s. 8d. per gal. Refined, 1s. 8d.—1s. 9d. per gal. Pale, 98%, 1s. 5d.—1s. 7d. per gal. Dark, 1s. 2d.—1s. 3d. per gal.

Anthracene Oil, Strained, 4¾d. per gal.

Benzole.—Prices at works: Crude, 10½d.—11d. per gal.; Standard motor, 1s. 6½d.—1s. 7d. per gal.; 90%, 1s. 7d.—1s. 8d. per gal.; Pure, 1s. 10d.—1s. 11d. per gal.

Xylol.—*1s. 10d.*—*2s. per gal. Pure, 1s. 11d.*—*2s. 2d.*

Creosote.—Standard specification, for export, 4¾d.—5d. net per gal., f.o.b. For home, 3¾d. per gal., d/d.

Naphtha.—Solvent 90/160, 1s. 4d.—1s. 6d. per gal. Solvent 95/160, 1s. 7d.—1s. 8d. per gal. Solvent 90/190, 11d.—1s. 2d. per gal.

Naphthalene.—Purified crystals, £9 10s. per ton in bags. Crude, Hot Pressed, £6 5s. per ton. Flaked. £11 per ton.

Pitch, medium, soft.—97s. 6d.—100s. per ton, in bulk at makers' works.

Pyridine.—90/140—3s. 9d. per gal.; 90/160—4s.—4s. 6d. per gal.; 90/180—2s.—2s. 3d. per gal.

Toluole.—90%, 1s. 10d.—2s. 1d. per gal. Pure, 2s. 3d.—2s. 5d. per gal.

PHARMACEUTICAL AND PHOTOGRAPHIC MATERIALS

Acid, Acetic, Pure 80%.—£39 5s. per ton d/d address U.K. in casks.

Acid, Acetyl Salicylic.—2s. 9d.—2s. 11d. per lb., according to quantity.

Acid, Benzoic, B.P.—1s. 9d.—1s. 11d. per lb. Solely ex Gum.—1s. 3d.—1s. 6d. per oz.; 50-oz. lots, 1s. 3d. per oz.

Acid, Boric, B.P.—Cryst., £35 10s. per ton. Powder, £36 10s. per ton. Ex-Fine Powder, £38 10s. per ton. For 1-ton lots and upwards, packed in 1-cwt. bags, carriage paid any station in Great Britain.

Acid, Camphoric.—*19s.*—*21s. per lb.*

Acid, Citric.—9¾d. per lb. Less 5%.

Acid, Gallic.—2s. 9d. per lb. for pure crystal in 1-cwt. lots.

Acid, Molybdic.—5s. 3d.—5s. 9d. per lb., according to quantity.

Acid, Pyrogallic. Cryst.—6s. 9d. per lb. for 1-cwt. lots. *Resublimed.*—*8s. 6d. per lb. for 28-lb. lots d/d.*

Acid, Salicylic.—B.P. pulv., 1s. 5d.—1s. 7d. per lb. Technical, 1s. 2d.—1s. 4d. per lb.

Acid, Tannic, B.P.—3s. 2d.—3s. 6d. per lb.

Acid, Tartaric.—10¾d. per lb. Less 5%.

Acetanilide.—1s. 5d. per lb.

Amidopyrin.—19s. 6d. per lb.

Ammon. Benzoate.—*3s. 3d. per lb.*

Ammon. Carbonate, B.P.—Lump, £36 per ton. Powder, £39 per ton, in 5-cwt. casks. Resublimed, 1s. per lb.

Ammonium Hippurate.—19s. 6d.—23s. 6d. per lb.

Ammonium Iodide.—17s.—17s. 6d. per lb.

Ammonium Molybdate.—5s.—5s. 6d. per lb., according to quantity.

Argent. Nitras, Crystal.—1s. 1d. per oz.

Arsenic Iodide.—22s. 6d.—25s. per lb.

Benzonaphthol.—3s. 3d.—3s. 9d. per lb.

Berberine, Hydrochloride.—5s. 6d.—6s. per oz.; Sulphate, 5s. 6d.—6s. per oz.

Bismuth Salts.—Carbonate, 6s. 10d. per lb.; Citrate, 9s. 3d. per lb.; Nitrate (cryst.), 4s. 7d. per lb.; Oxide, 10s. 6d. per lb.; Salicylate, 7s. 7d. per lb.; Subchloride, 10s. 3d. per lb.; Subgallate, 7s. 3d. per lb.; Subnitrate, 5s. 11d. per lb. Above for cwt. lots. Extra and reduced prices for smaller and larger quantities respectively. Liquor Bismuthi, P.B., in W. Qts.—1s. 1½d. per lb.; 6 W. Qts.—11d. per lb.; *12 W. Qts.*—*9½d. per lb.; 36 W. Qts.*—*9d. per lb.*

Borax, B.P.—Crystal, £24 10s. per ton. Powder, £25 per ton. For 1-ton lots and upwards, packed in 1-cwt. bags, carr. paid any station in Great Britain.

Bromides, B.P.—Ammonium.—1s. 10d. per lb. Potassium.—1s. 7d. per lb. Sodium.—1s. 9d. per lb. Prices for 1-cwt. lots.
Cadmium Iodide.—17s. 6d.—18s. per lb.
Calcium Hippurate.—26s.—30s. per lb.
Calcium Iodide.—20s. per lb.
Calcium Lactate, B.P.—1s. 2d.—1s. 4d. per lb., according to quantity.
Camphor.—Refined flowers, 3s. 1d.—3d. 3d. per lb. Transparent tablets, 3s. 4d.—3s. 6d. per lb., according to quantity; also special contract prices.
Chloroform.—2s. 3d.—2s. 8d. per lb.
Cocaine, Alkaloid and Citrate.—For export.—29s. 10d.—31s. 7d. per oz. Hydrochloride and Nitrate, 27s. 1d.—28s. 11d. per oz.
Ergosterol.—2s. 6d. per gm.
Ethers.—S.G. 730, 1s. 1d.—1s. 2d. per lb., according to quantity, and other prices according to specific gravity.
Hexamine.—2s. 6d.—2s. 10d. per lb., according to quantity.
Hippuric Acid.—17s. 6d.—21s. 6d. per lb.
Hydrogen Peroxide (12 vols.).—1s. 4d. per gal., f.o.r. makers' works, naked. B.P.—10 vols., 2s.—2s. 3d. per gal.; 20 vols., 3s. per gal.
Hypophosphites.—Calcium, 2s. 9d.—3s. 2d. per lb. Potassium.—3s.—3s. 5d. per lb. Sodium, 2s. 11d.—3s. 4d. per lb.
Iodine Resub., B.P.—15s. 2d.—19s. 3d. per lb.
Iodoform, B.P., Cryst., Precip. or Powder.—18s. 2d.—22s. 2d. per lb.
Iron Ammon. Citrate.—B.P.—1s. 7d. per lb. for 28-lb. lots. Green, 2s. 6d. per lb. (list price).
Iron Iodide.—17s. 6d.—18s. per lb.
Iron Perchloride.—18s.—20s. per cwt., according to quantity.
Iron Quinine Citrate, B.P.—9½d.—10d. per oz., according to quantity.
Lead Iodide.—14s.—15s. per lb.
Lithium Carbonate, B.P. 1914.—5s. 4d. per lb.
Lithium Chloride, Cryst.—8s. 3d. per lb.
Lithium Citrate.—5s. 3d. per lb. Powder.—5s. 6d. per lb.
Lithium Hippurate.—18s. 6d.—22s. 6d. per lb.
Lithium Iodide.—20s. 6d.—21s. 6d. per lb.
Magnesium Carbonate.—Light, 28s. per cwt.
Magnesium Oxide.—Light, 70s. per cwt.; Heavy, 1s. 8d. per lb.; in quantity lower.
Menthol.—A.B.R., recryst., B.P., 18s. 6d. per lb. net. Synthetic, 8s. 6d.—12s. per lb. Synthetic detached crystals, 8s. 6d.—10s. per lb., according to quantity; Liquid (95%), 8s. 6d. per lb.
Mercurials, B.P.—Red oxide crystals, 5s. 10d.—5s. 11d. per lb.; Levig, 5s. 4d.—5s. 5d. per lb.; Corrosive sublimate, Lump, 4s.—4s. 1d. per lb.; Powder, 3s. 8d.—3s. 9d. per lb.; White precip., Lump, 4s. 9d.—4s. 10d. per lb.; Powder, 4s. 11d.—5s. per lb.; Calomel, 4s. 9d.—4s. 10d. per lb. Yellow Oxide, 5s. 2d.—5s. 3d. per lb.; Persulph., B.P.C., 4s. 11d.—5s. per lb.; Sulph. nig., 4s. 10d.—4s. 11d. per lb. Special prices for larger quantities.
Mercury, Benzoate.—8s. 3d. per lb.; Cyanide, 12s. 7d.—13s. 1d. per lb.; Oleate (5%), 1s. 11d.—2s. 2d. per lb.; (10%), 2s. 9d.—3s. per lb.; (20%), 3s. 9d.—4s. per lb. Protonitras, 6s. 9d. per lb.; Protosulphate, 7s. 3d. per lb.; Subsulphate flav., 7s. 1d. per lb.
Methyl Salicylate.—1s. 4½d.—1s. 6½d. per lb.
Paraformaldehyde.—1s. 3d.—1s. 5d. per lb.
Paraldehyde.—1s. 1d. per lb.
Phenacetin.—4s. 6d.—4s. 9d. per lb.
Phenolphthalein.—4s. 5d.—5s. 8d. per lb.
Potass. Bitartrate.—99/100% (Cream of Tartar), 85s. per cwt., less 2½%.
Potass. Citrate.—B.P., 1s. 5d. per lb. for 28-lb. lots.
Potass. Ferricyanide.—1s. 7½d. per lb., in 125-lb. kegs.
Potass. Iodide, B.P.—13s. 5d.—15s. 11d. per lb., according to quantity.
Potass. Permanganate.—8½d. per lb. for 1-ton lots.
Potass. Metabisulphite.—50s. per cwt. d/d London, kegs free.
Potassium Hippurate.—26s.—30s. per lb.
Quinine Sulphate.—2s. 6d. per oz., for 100-oz. tins, tins free.
Saccharin.—37s. 6d. per lb., and lower in quantity.
Salicin.—15s.—16s. per lb., according to quantity.
Santonin.—£50 per kilo for 5-kilo lots.
Seidlitz powder (pulv.).—66s. 3d.—70s. per cwt.
Silver Nitrate.—1s. 3¼d. per oz. for quantity. Sticks, 2d. per oz. extra.
Sod. Barbitonum.—12s. 9d.—14s. per lb.
Sod. Benzoate, B.P.—1s. 7d. per lb., according to quantity.
Sod. Citrate, B.P.C., 1911.—1s. 2d. per lb. B.P.C., 1923, and U.S.P.—1s. 6d. per lb. for 28-lb. lots.
Sodium Hippurate.—23s. 6d.—27s. 6d. per lb.
Sod. Hyposulphite.—Photographic, £15 per ton d/d consignee's station, in 1-cwt. kegs.
Sodium Iodide, B.P.—14s. 5d.—17s. 6d. per lb.
Sod. Nitroprusside.—16s. per lb.
Sod. Potass. Tartrate (Rochelle Salt).—75s. per cwt. net for 1-ton lots. Crystals, 2s. 6d. per cwt. extra.
Sod. Salicylate.—Powder, 2s.—2s. 8d. per lb. Crystal, 2s. 1d.—2s. 9d. per lb.
Sod. Sulphide.—Pure recryst., 10d.—1s. 2d. per lb.
Sod. Sulphite anhydrous.—£23—£25 per ton, according to quantity, d/d U.K.
Strontium Iodide.—17s. 6d. per lb.
Tartar Emetic B.P. cryst. or powder.—1s. 9d.—2s. per lb.
Terpine hydrate.—1s. 2d.—1s. 5d. per lb.
Thymol, Puriss.—5s. 9d.—6s. 6d. per lb., according to *quantity. Natural.*—12s. per lb.
Zinc Iodide.—21s.—22s. per lb.
Zinc Stearate.—1s. 4d.—1s. 6d. per lb.

PERFUMERY CHEMICALS

Acetophenone.—7s. per lb.
Aubepine (*ex Anethole*).—8s. 9d. per lb.
Amyl Acetate.—2s. 3d. per lb. Amyl Butyrate.—5s. per lb. Amyl Cinnamic Aldehyde.—8s. 6d. per lb. Amyl Salicylate.—2s. 9d. per lb. Anethol, 21/22° C., 5s. 3d. per lb.
Benzaldehyde free from Chlorine.—3s. per lb.
Benzyl Acetate from Chlorine-free Benzyl Alcohol.—1s. 9d. per lb. Benzyl Alcohol free from Chlorine.—1s. 9d. per lb. Benzyl Benzoate, 2s. 1d. per lb.
Cinnamic Aldehyde.—Natural, 12s. 6d. per lb.
Citronellol.—8s. 6d. per lb.
Citral.—6s. 6d. per lb.
Coumarin.—14s. 6d. per lb.
Ethyl Cinnamate.—7s. 6d. per lb.
Ethyl Phthalate.—2s. 6d. per lb.
Eugenol.—7s. 6d. per lb. Geraniol (Palmarosa).—17s. 3d. per lb. Geraniol.—6s. 6d.—11s. per lb. *Heliotropine.*—5s. 9d. per lb. Iso Eugenol.—9s. per lb. Linalol.—(*ex Bois de Rose*) 7s. per lb.—(*ex Shui Oil*) 6s. per lb. Linalyl Acetate.—(*ex Bois de Rose*) 9s. per lb.—(*ex Shui Oil*) 7s. 6d. per lb.

Methyl Anthranilate.—8s. 6d. per lb.
Methyl Benzoate.—4s. 3d. per lb.
Musk Ketone.—30s. per lb.
Musk Xylol.—6s. 6d. per lb.
Nerolin.—4s. per lb.
Phenyl Ethyl Acetate.—10s. per lb.
Phenyl Ethyl Alcohol.—8s. 6d. per lb.
Rhodinol.—60s. per lb. Safrol.—1s. 7d. per lb. Terpeneol.—1s. 6d. per lb. Vanillin (*ex Clove Oil*).—16s.—18s. per lb.—(*ex Guaiacol*)—14s. 3d.—16s. 3d. per lb.

ESSENTIAL OILS

Almond. Foreign S.P.A., 11s. 6d. per lb. Anise.—2s. 2d. per lb. Bergamote.—8s. per lb. Bourbon Geranium, 24s. 6d. per lb.
Camphor. Brown, 90s. per cwt. White, 90s. per cwt. Cananga, Java, 11s. per lb. Cinnamon Oil.—4s. 3d. per lb. Cassia, 80/85%, 4s. 3d. per lb.
Citronella Oil.—Java, 3s. per lb. Ceylon, 2s. 4d. per lb. Clove—90/92% English, 4s. 10d. per lb.
Eucalyptus, Australian B.P., 70/75%,—1s. per lb. Lavender.—Mont Blanc, 38/40%,—11s. 3d. per lb. Lemon 5s. 6d. per lb. Lemongrass—3s. per lb. Orange, Sweet.—6s. 6d. per lb. Otto of Rose.—Anatolian, 42s. 6d. per oz.; Bulgarian, 62s. 6d. per oz. Palma Rosa, 9s. 6d. per lb.
Peppermint.—Japanese, 6s. 9d. per lb. Wayne County, 14s. per lb. Petitgrain.—6s. 3d. per lb.
Sandalwood. Mysore, 30s. per lb. 90/92%, 19s. 3d. per lb.

INTERMEDIATES

Items marked thus * d/d buyers' works.

*Acid, Benzoic, 1914 B.P. *ex Toluol.*—1s. 9½d. per lb. in casks.
*Acid Gamma.—Spot, 4s. per lb., 100%.
*Acid H.—Spot, 2s. 4½d. per lb., 100%.
*Acid Neville and Winther.—Spot, 3s. per lb., 100%.
*Acid Sulphanilic, 8d. per lb.
*Aniline Oil, spot, 8d. per lb., drums extra.
*Aniline Salts, spot, 8d. per lb., casks free.
*Benzaldehyde, spot, 1s. 8d. per lb., packages extra.
*Benzidine Base.—Spot, 2s. 5d. per lb., 100%.
o-Cresol 30/31° C.—£2 6s. 5d. per cwt. in 1-ton lots.
m-Cresol 98/100%.—2s. 3d. per lb., in ton lots.
p-Cresol 34.5° C.—1s. 9d. per lb., in ton lots.
Dichloraniline.—2s. per lb.
*Dimethylaniline.—Spot, 1s. 6d. per lb., packages extra.
Dinitrobenzene.—8½d. per lb.
Dinitrotoluene 48/50° C.—8¾d. per lb. 66/68° C.—9d. per lb.
*Diphenylamine.—Spot, 2s. per lb.
*α-Naphthol.—Spot, 2s. 4d. per lb.
*β-Naphthol.—Spot, £78 15s. per ton, in paper bags; £79 15s. per ton in casks, in 1-ton lots.
*α-Naphthylamine.—Spot, 11½d. per lb.
*β-Naphthylamine.—Spot, 2s. 9d. per lb.
o-Nitraniline.—5s. 10d. per lb.
**m*-Nitraniline.—2s. 7d. per lb.
**p*-Nitraniline.—Spot, 1s 8d. per lb
*Nitrobenzene.—Spot, 4½d. per lb., 5-cwt. lots, drums extra.
Nitronaphthalene.—9d. per lb.
*Sodium Naphthionate.—Spot, 1s. 9d. per lb., 100%.
**p*-Toluidine.—Spot, 1s. 11d. per lb.
**o*-Toluidine.—Spot, 9½d. per lb., drums extra.
m-Xylidine acetate, 3s. 6d. per lb., 100%.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. British firms may obtain further information by applying to the Department and stating the specific number. *Argentina:* Tinplate (151). *British India:* Sodii salicylas B.P. etc., essential oils etc., bismuthi subnitras, carbonas, and salicylas B.P., iodum and iodoformum B.P., santoninum B.P., cresol saponified (Director-General, India Store Department, Belvedere Road, Lambeth S.E.1). *British West Indies:* Oleum (sulphuric acid) (123). *Canada:* Air compressors (gasoline and Diesel driven) (124). *Egypt:* Paper (B.X. 7492): Oils etc. for soap making (B.X. 7491). *South Africa:* Chemical treatment plant, chemical mixing plant, flocculating plant, filtration plant, chlorinating plant (G.X. 12,220). *Switzerland:* Industrial chemicals (145).

Import Duties

The Board of Trade announces that regulations have been made under Section 8 (1) of the Finance Act, 1919, and paragraph 1 of the 3rd Schedule to the Import Duties Act, 1932, prescribing that certain classes of goods manufactured in, and consigned from, a part of the Empire must contain a minimum of 50% of Empire material and labour in order to qualify for Imperial Preference, instead of 25% as at present. The Regulations, will come into force on April 1, 1933, and copies will be obtainable from H.M. Stationery Office, Adastral House, Kingsway, W.C.2, either direct or through any bookseller.

Key Industries

A representation has been made to the Board of Trade regarding acid carbolic (synthetic), under Section 10 (5) of the Finance Act, 1926, which is as follows:

"The Treasury may by order exempt from the duty imposed by Section 1 of the Safeguarding of Industries Act, 1921, as amended by this Act, for such period as may be specified in the order, any article in respect of which the Board of Trade are satisfied on a representation made by a consumer of that article that the article is not made in any part of His Majesty's Dominions in quantities which are substantial having regard to the consumption of that article for the time being in the United Kingdom, and that there is no reasonable probability that the article will within a reasonable period be made in His Majesty's Dominions in such substantial quantities."

Any communication should be addressed to the Principal Assistant Secretary, Industries and Manufactures Department, Board of Trade, Great George Street, S.W.1, before February 24, 1933.

National "Safety First" Association

The new address of the National "Safety First" Association (Inc.) is Terminal House, 52, Grosvenor Gardens, London, S.W.1, and the telephone numbers are changed to Sloane 2188 and 2189. The telegraphic address remains unchanged, viz.: "Safeguards, Sowest, London."